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The Strength of Wire Rope Fasteners

Mechanical Engineering

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THE STRENGTH OF WIRE ROPE FASTENERS

BY

LOUIS SMITH FERGUSON
EDWARD ROSS LUNEY

THESIS

FOR

DEGREE OF BACHELOR OF SCIENCE

IN

MECHANICAL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

1913

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Louis Smith Ferguson and Edward Ross Luney

ENTITLED The Strength of Wire Rope Fasteners

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Mechanical Engineering

H. F. Moore

Instructor in Charge

APPROVED: C. P. Richards

HEAD OF DEPARTMENT OF Mechanical Engineering

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Table of Contents.

UIUC

STRENGTH OF WIRE ROPE FASTENERS.

Preliminary.

I. Reasons for the Thesis;

Due to the small amount of work that has heretofore been done in determining the strength and efficiency that the various wire rope fasteners, which are used in guy wire practice of today, will develop , the writers have run tests ~~to~~ primarily to determine the strength and efficiency of the fasteners with relation to the rope for which they are designed. Very little data was available to work from, due to the small amount of work which has been done along these lines. For this reason a series of tests were made in the Laboratory of Applied Mechanics of the University of Illinois.

II. Where the fasteners are used;

Fasteners of the nature used in this Thesis are those common to the guy wire rope practice of today and are sold by all the leading wire rope manufacturers. Data concerning the ease and quickness in applying them, their efficiencies, and strengths are found in the following pages. Curves showing the slip due to the loads on the ropes in various methods of application are given.

III. Rope used and why;

The rope used in this Thesis is Siemons-Martin Special Extra Galvanized Strand of seven wires, (Fig. III) the kind used and the type of rope for which the fasteners are designed and is described in Part II. In addition, this style and type of rope is most extensively used in all guy rope practice.

IV. Division of Tests;

The tests were divided into four series. The first series ~~being~~ comprised straight tension of two pieces of wire rope fastened together with one or more clips. The second series ~~being~~ comprised tests where the rope was wrapped around a 6" cast iron pipe, this being about the size of the average pole. The third ~~being~~ series was similiar to series No. 2. The fourth series consisted of tests made on the various ropes to determine their strengths. These tests are described more fully in Part II.

Part II.

Test Pieces and Tests.

V. Rope; description and sizes;

Three sizes of rope were used with the various fasteners. The sizes used were namely: 1/4", 3/8", and 1/2". Each rope was made up of 7 strands of galvanized wire twisted together into a single strand. (Fig. III) The 1/2" rope consists of 7 strands of No. 6, B. & S. guage twisted together; the 3/8", of 7 No. 9. B. & S. guage, and the 1/4", of 7 No. 13. B. & S. guage. All these were made the same and were galvanized. A few tests were made on extra strength 3/8", of 7 No. 9 B. & S. guage, and some 7/16", 7 No. 6 B. & S. guage.

VI. Fasteners; description and sizes;

The fastenings tested are those common today in guy wire fastening, namely: the Three Bolt Clamp, (Fig. II); the Cook; the Crosby, (Fig.I); and three forms of the Mathews Boltless;- the Baby, (Fig. V), Giant, (Fig. IV), and the Open Back.

The Crosby Clip used on the 1/2" and 3/8" rope is galvanized. It consists of a flat piece of metal, (Fig. I), with a groove in the center in which the rope is laid. The other end of the wire is laid over this and a U bolt is placed over the wire and thru the holes of the grooved base. The clip is then tightened by means of the nuts on the bolt legs.

The flat clips are all similiar. The Cook galvanized clamp consists of two pieces with teat projections into which the rope is laid. Both ends of the rope laid side by side and the flat pieces placed on top of one another and fastened together by means of bolts.

The Flat Three Bolt clamp is similiar to the Cook except there are no teat projections, but only a groove on each side of the bolt holes. The rope is laid in the clamp similiar to the method of the Cook.

The Matthews is a new style of clip, ~~sheridized~~ and consisting of a wedge-cored collar into which the wires are thrust. A wedge which fits inside this collar is then driven thru against the wires and the sides of the collar, gripping the wires very tightly. As the wire tends to move thru the clamp the wedge tightens and holds the wire even more securely. A new style of this clamp, called the Open Back, was tried. It has an open back which allows the rope to be slipped in without being laced in from the ends as in the other style. The other styles of Matthews tried had a round backed wedge fitting against a flat collar and another against a round collar.

VII. Testing Machines and Apparatus;

All tests were made in the Laboratory of Applied Mechanics. They were, with the exception of a few run on a 50 000 lb. Riehle Testing Machine, made on a 100 000 lb. Riehle Testing Machine. The single wire tests of the ropes were made on a 10 000 lb. Olsen Testing Machine.

Fig. IX shows a test on the 100 000 lb. Riehle of series III.

The slip was recorded by an extensometer whose dial is graduated into 1/1,000". A fine insulated copper wire No. 36 was used by fixing one end to the clamp and the other end being wrapped around the drum of the extensometer needle and was

weighted and allowed to hang free. The circumference of the needle drum was 1" thus making the revolution of the needle show 1" slip. The dial of the extensometer was clamped to the cable end which was held in the grips. This apparatus is shown in Fig. IX.

VIII. Methods of testing;

The first series of tests (Fig. VI), were made upon the fasteners in single tension. That is, two pieces of rope were fastened together by means of one or more fasteners, and then a straight tension test was made.

In the second series, the grips and holder were removed from the top of the machine. A 6" iron pipe was then placed crosswise with some hardwood blocks beneath each end. (Fig. VII.) This was to hold the pipe high enough so that the wire did not come in contact with the machine. The wire rope was given one complete wrap around the pipe and then a fastener or fasteners were used to fasten the free end to the end that went to lower grips.

In the third series the order was reversed and a 7" pipe was placed on the top of the movable head and secured with three bolts. The cable was then fastened in the top grips and the test was run as in the second series. Fig. VIII and IX.

The fourth series were tests showing the strength of the strands and the single wires. These were all straight tension tests. The first set of tests consists of Tests No. 1 to No. 49 inclusive, with the exception of the fourth series. The second set consists of Tests No. 50 to No. 73 inclusive. The third set comprises Tests No. 74 to No. 79 inclusive. The fourth comprises Tests No. 5, 14, 20, 15, 36, 37, 70, 76, 77. From these tests the

efficiencies of the cable was determined.

The extensometer was used on all tests in the first three sets and the readings were taken at convenient loads. It was not used in the fourth set as only the ultimate strength was desired.

Figure I.

Figure II.

Figure III.

Figure IV.

Figure V.

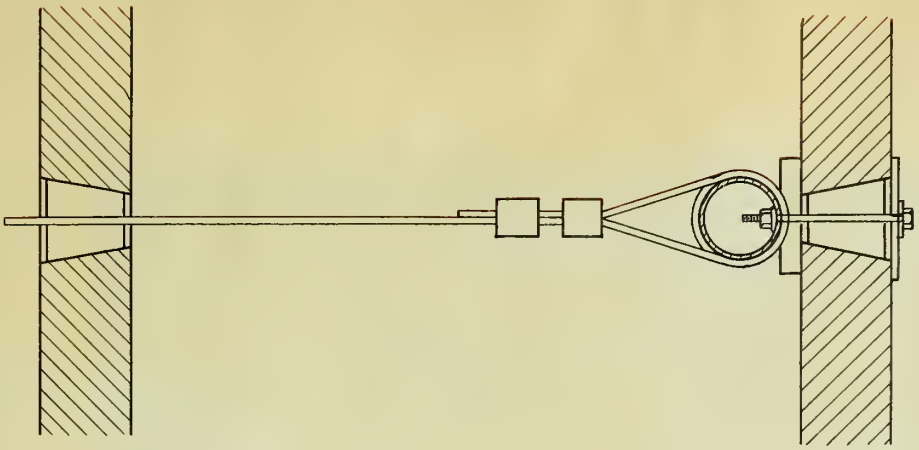


Fig. VIII.

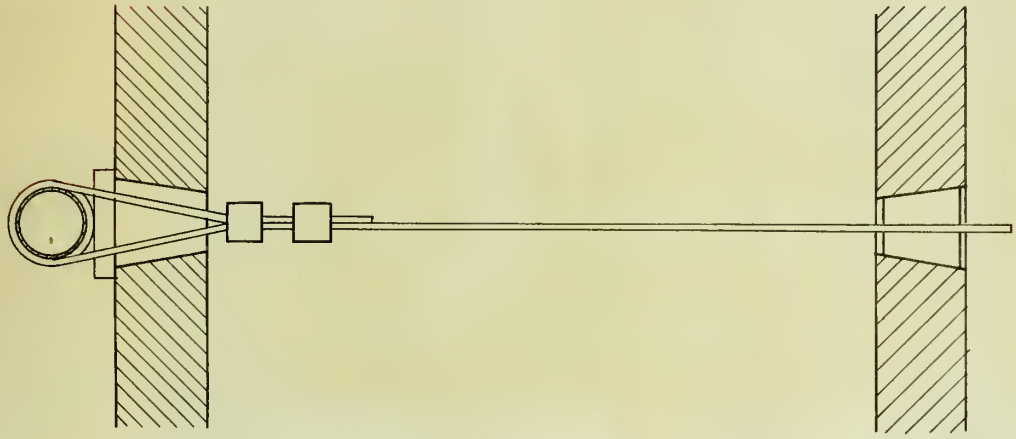


Fig. VII.

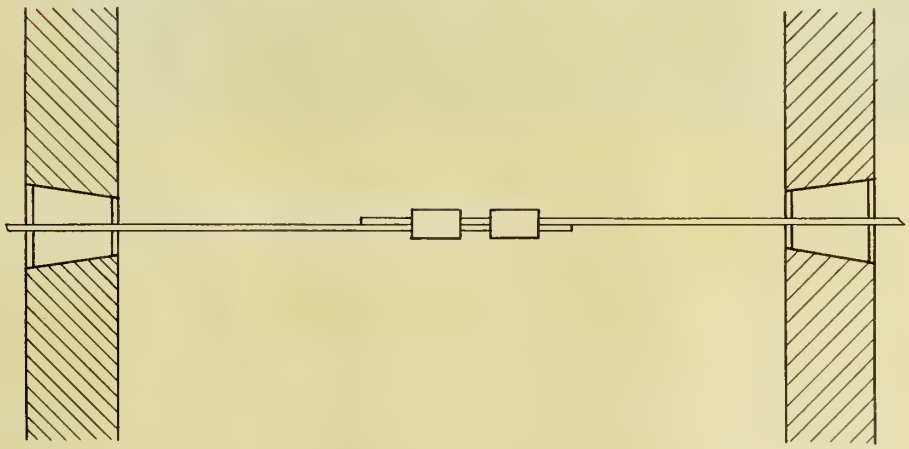


Fig. VI.

Figure IX.

Table I.

Strength of Wire rope(7 strands in rope).

Test No:	Dia. in:	Ulti. Str. Experimental:	Strength of Strand.	Efficiency in percent:	Average percent.
14	1/2"	11,000	1,575	100.0	
15	1/2"	11,000	1,675	93.5	
20	1/2"	10,900	1,600	97.5	
21	1/2"	10,900	1,700	91.9	99.5
36	3/8"	5,560	800	91.5	
37	3/8"	5,480	790	99.1	99.3
70	1/4"	2,348	350	97.2	
70	1/4"	2,330	342	97.4	
70	1/4"	2,350	367	91.6	
70	1/4"	2,335	340	98.2	96.2
76	3/8"	6,510	960	97.0	
76	3/8"	6,760	1,060	91.5	
76	3/8"	6,740	990	97.2	95.2
77	7/16"	9,120	1,314	99.2	
77	7/16"	9,120	1,304	99.7	
77	7/16"	9,170	1,320	99.3	99.4

The efficiencies were found by multiplying the strength of the strands by seven, and dividing the experimental value of the Ultimate strength of the rope by this product.

Table II.

Holding strength of various clamps in tension.

Test No:	Clamp used:	No. used:	Rope size:	Ult.holding load. Avg,lbs.	Ult.holding load-Clip:	Manner of failure.
1,2	Crosby	1	1/2"	1,400	1,400	Slip of Clip.
3,4	Crosby	2	1/2"	3,260	1,630	Slip of Clip
6,13	Crosby	3	1/2"	5,125	1,700	Slip of Clip
12	Crosby	4	1/2"	8,400	2,100	Slip of Clip
22	Crosby	5	1/2"	9,000	1,800	Slip of Clip
24	Crosby	6	1/2"	9,800	1,640	Slip of Clip
26,27	Crosby	7	1/2"	10,350	1,480	Cable broke
25	Crosby	8	1/2"	10,620	1,320	Cable broke
34,38	Crosby	1	3/8"	1,930	1,930	Slip of Clip
7,29,30	Three Bolt	1	1/2"	1,680	1,680	Slip of Clip
8	Three Bolt	2	1/2"	2,500	1,350	Slip of Clip
10	Three Bolt	3	1/2"	3,800	1,270	Slip of Clip
11	Three Bolt	4	1/2"	5,000	1,250	Slip of Clip
31	Three Bolt	5	1/2"	9,000	1,800	Slip of Clip
42,46	Three Bolt	1	3/8"	3,250	3,250	Cable broke
48,49	Three Bolt	2	3/8"	5,560	2,780	Cable broke
35,43	Crosby	3	3/8"	5,335	1,770	Cable broke

Table III.

Holding strength of clamps when rope has one complete wrap around a six inch cast iron pipe.

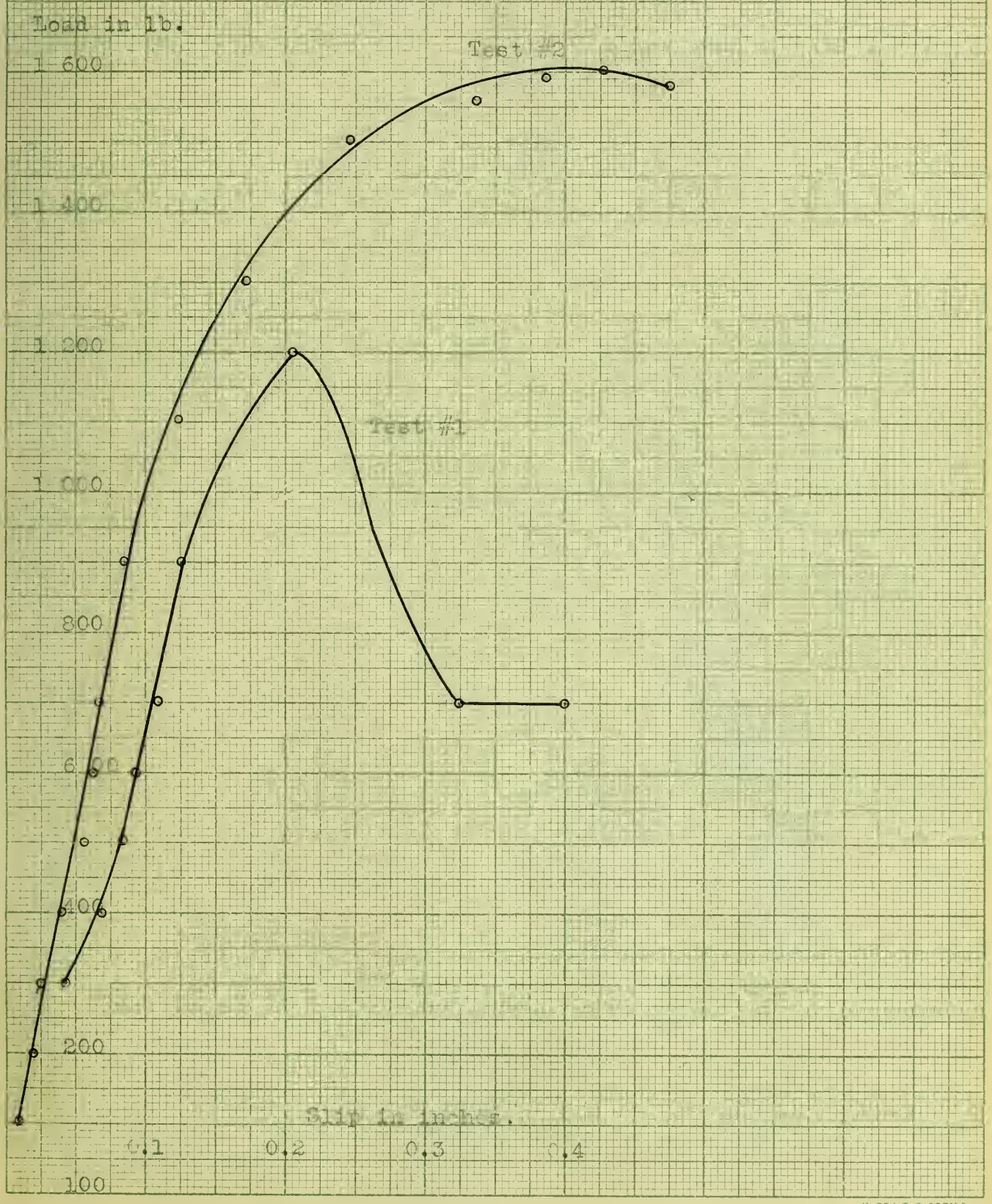
Test No:	Clip used:	No. used:	Rope size:	Ult. load Avg. lbs.	Ult. load per clip lbs.	Manner of failure.
50,51	Matthews	1	3/8"	2,900	2,900	Slip of Clamp
52,53	Matthews	1	3/8"	3,750	3,750	Slip of Clamp
55,56	Matthews	1	1/4"	2,150	2,150	Cable broke
55*,56*	Matthews	2	3/8"	5,620	3,810	Cable broke
57	Matthews	1	1/4"	1,850	1,850	Cable broke
58,63	Matthews	1	3/8"	5,640	5,640	Cable broke
59,64	Matthews	1	3/8"	5,570	5,570	Cable broke
61,62	Matthews	1	3/8"	5,560	5,560	Cable broke
66,67	Crosby	1	3/8"	5,500	5,500	Cable broke
68,69	Three Bolt	1	3/8"	5,600	5,600	Cable broke
71,72	Cook	1	3/8"	4,150	4,150	Slip of Clamp
73	Crosby	1	1/2"	8,000	8,000	Pipe broke

The following tests are of Series No. III. and the pipe used is seven inches in diameter.

74	Matthews	1	3/8"	5,000	5,000	Slip of clamp
75	Matthews	1	3/8"	6,280	6,280	Cable broke
78	Matthews	1	7/16"	8,840	8,840	Cable broke
79	Matthews	1	7/16"	8,250	8,250	Slip of clamp,

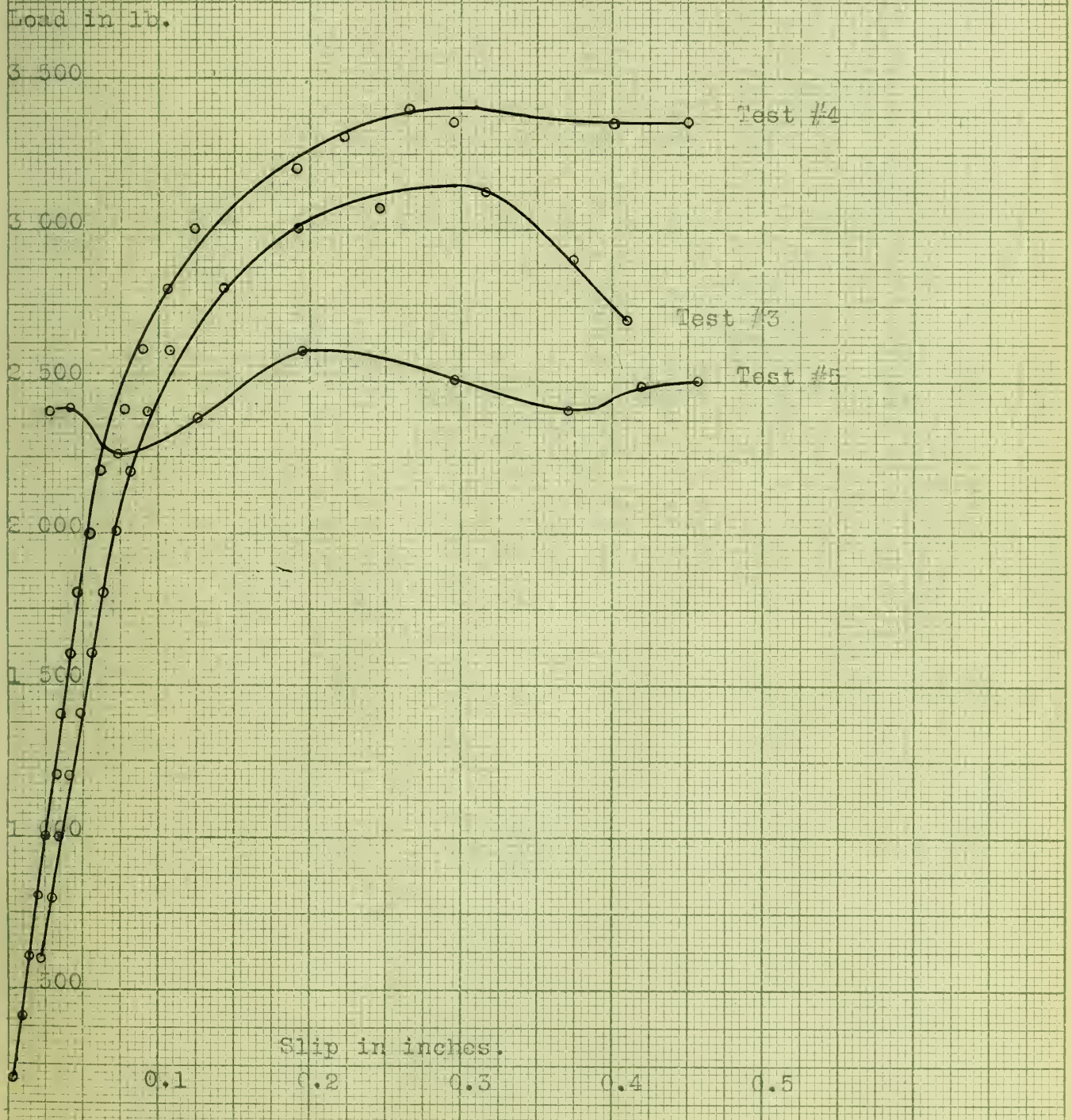
The last four tests recorded on this page were run with extra strong strand, and with the Matthews Giant Arched-Backed clamp.

TESTS #1 & #2.
Single Crosby Clip.
Tension Tests with 1/2" Rope.



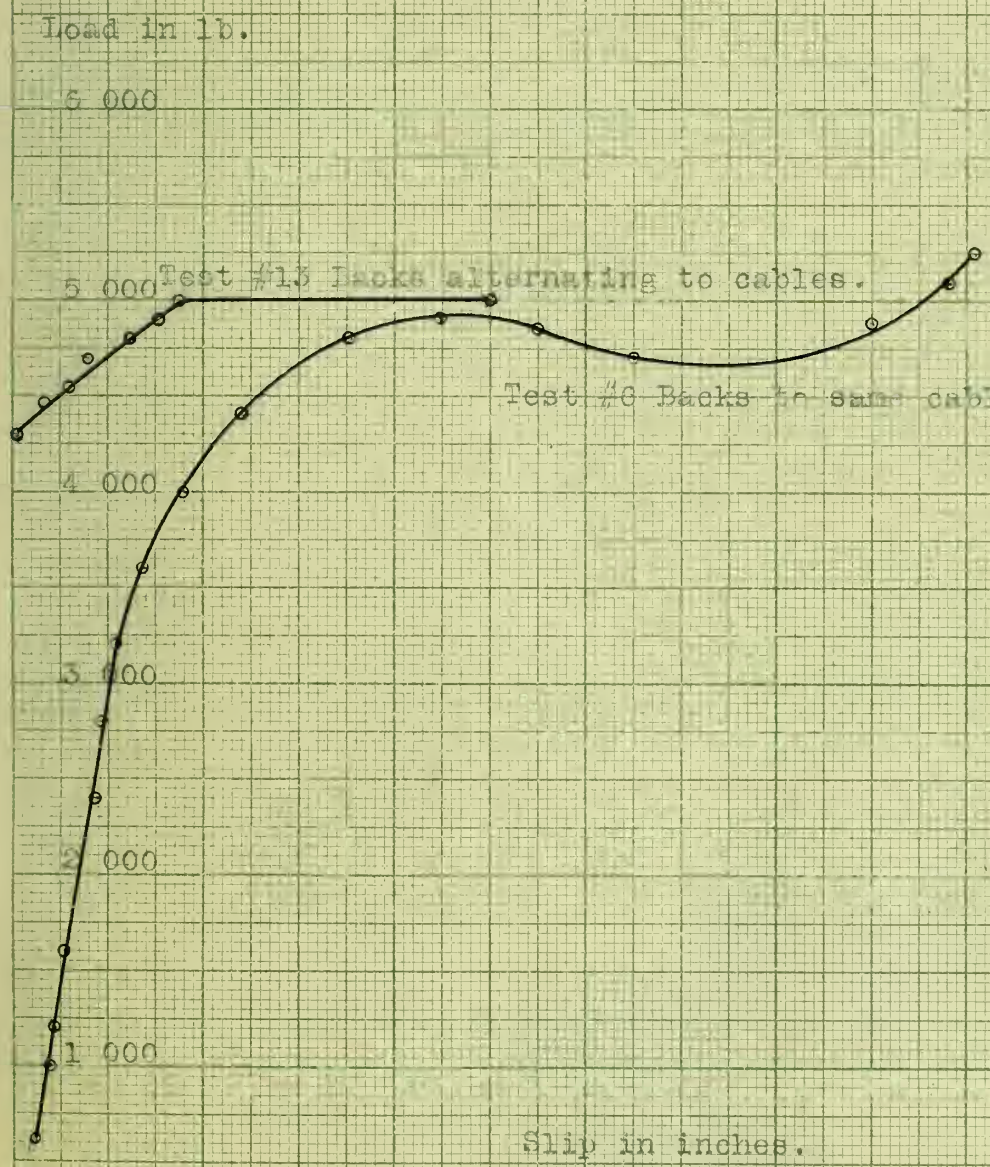
U OF I. S. S. FORM 3

TWO CROSBY CLIPS.
TEST #3 & #4,- BACKS ALTERNATING.
TEST #5,- BACKS TO SAME CABLE.
TENSION TESTS WITH 1/2" ROPE.



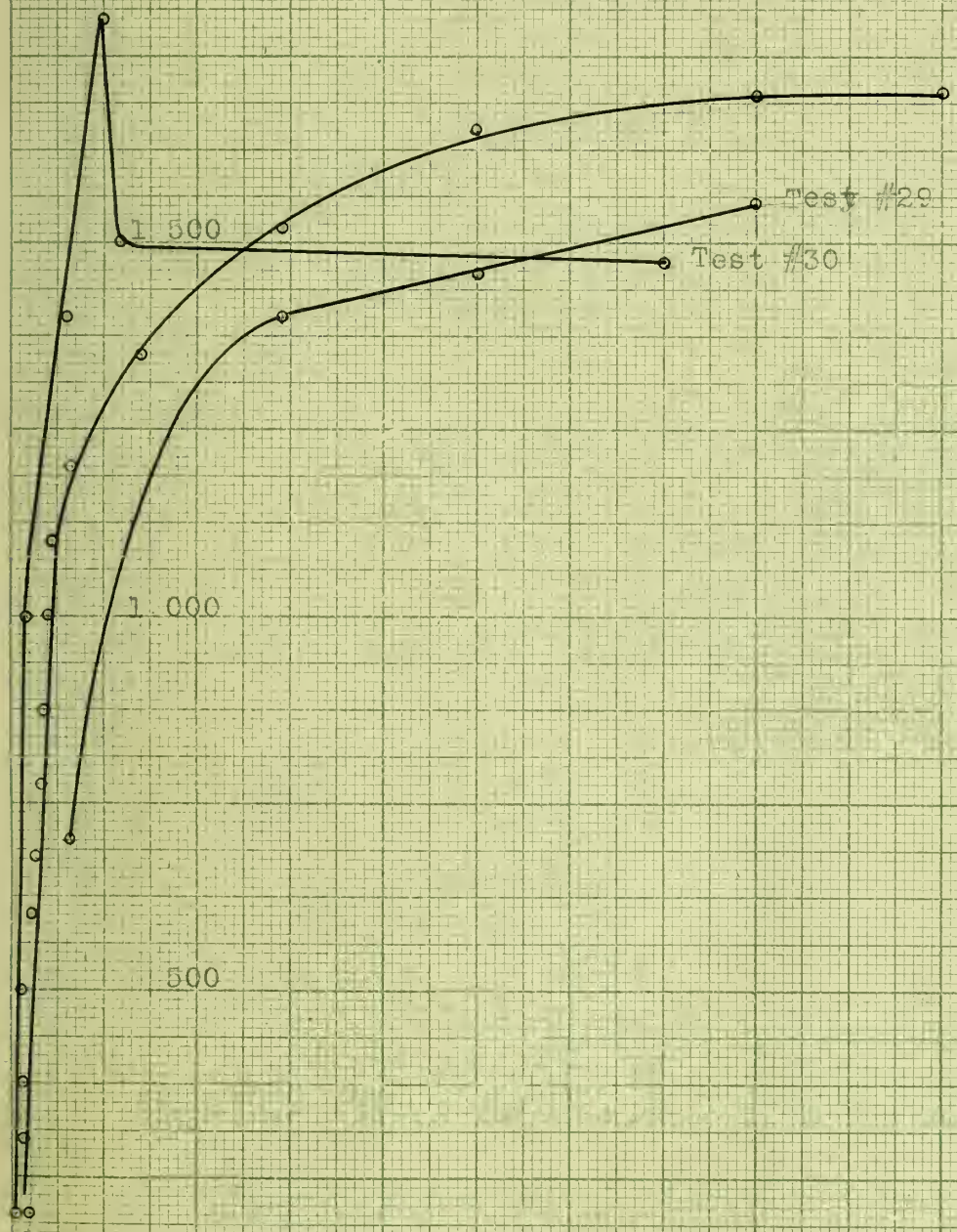
U. OF I. S. S. FORM 3

TESTS #6 & #13.
THREE CROSBY CLIPS.
TENSION TESTS WITH 1/2" ROPE.



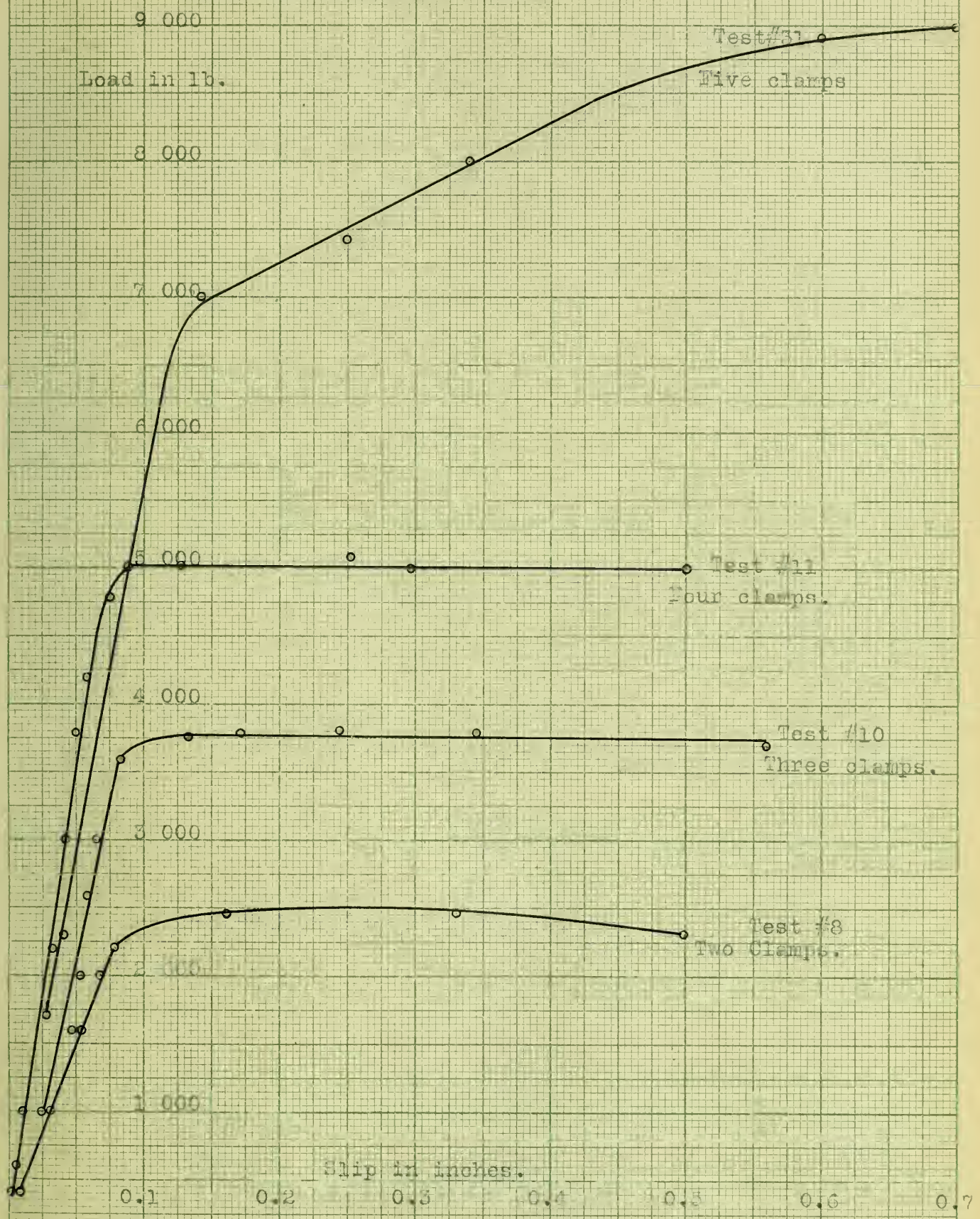
U OF S S FORM 3

TESTS #7 & #29 & #30.
ON THREE BOLT CLAMP.
TENSION TEST WITH 1/2" ROPE.



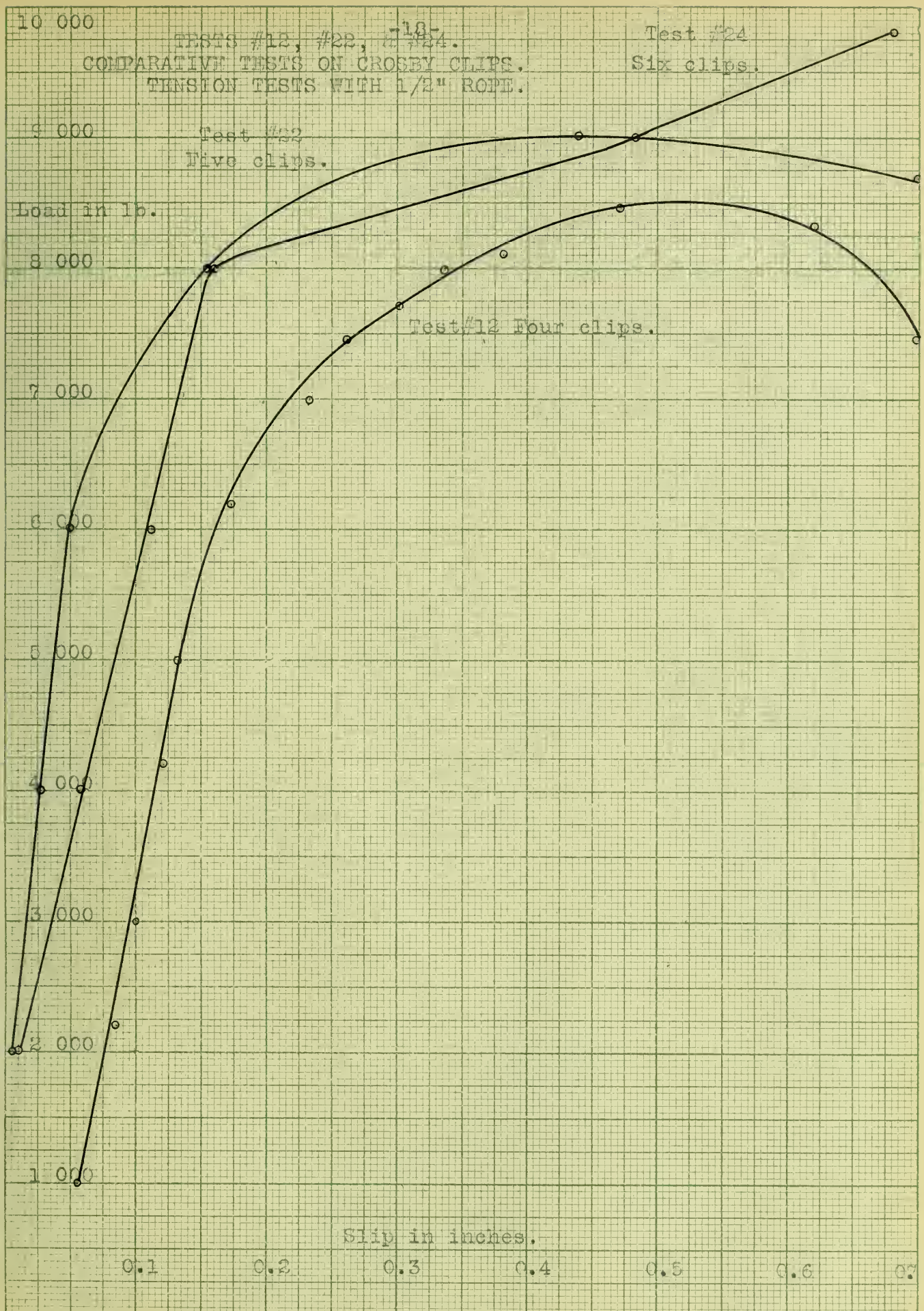
U. OF I. S. S. FORM 3

TESTS #8, #10, #11, & #31
COMPARATIVE TESTS ON SHERMAN BOLT CLAMPS.
TENSION TESTS WITH 1/2" ROPE.



U. OF I. S. S. FORM 3

TESTS #12, #22, #24.
COMPARATIVE TESTS ON CROSBY CLIPS.
TENSION TESTS WITH 1/2" ROPE.



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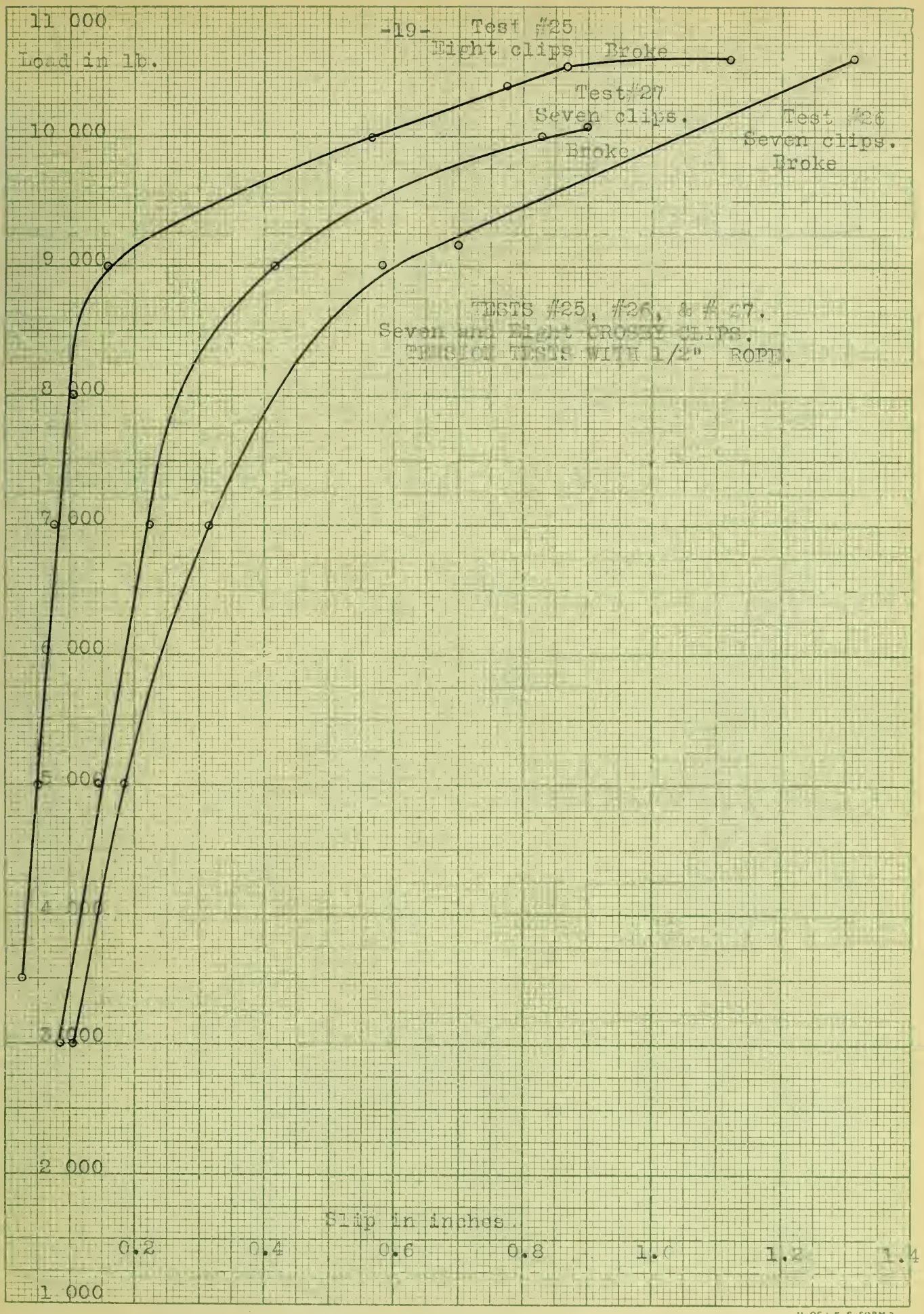
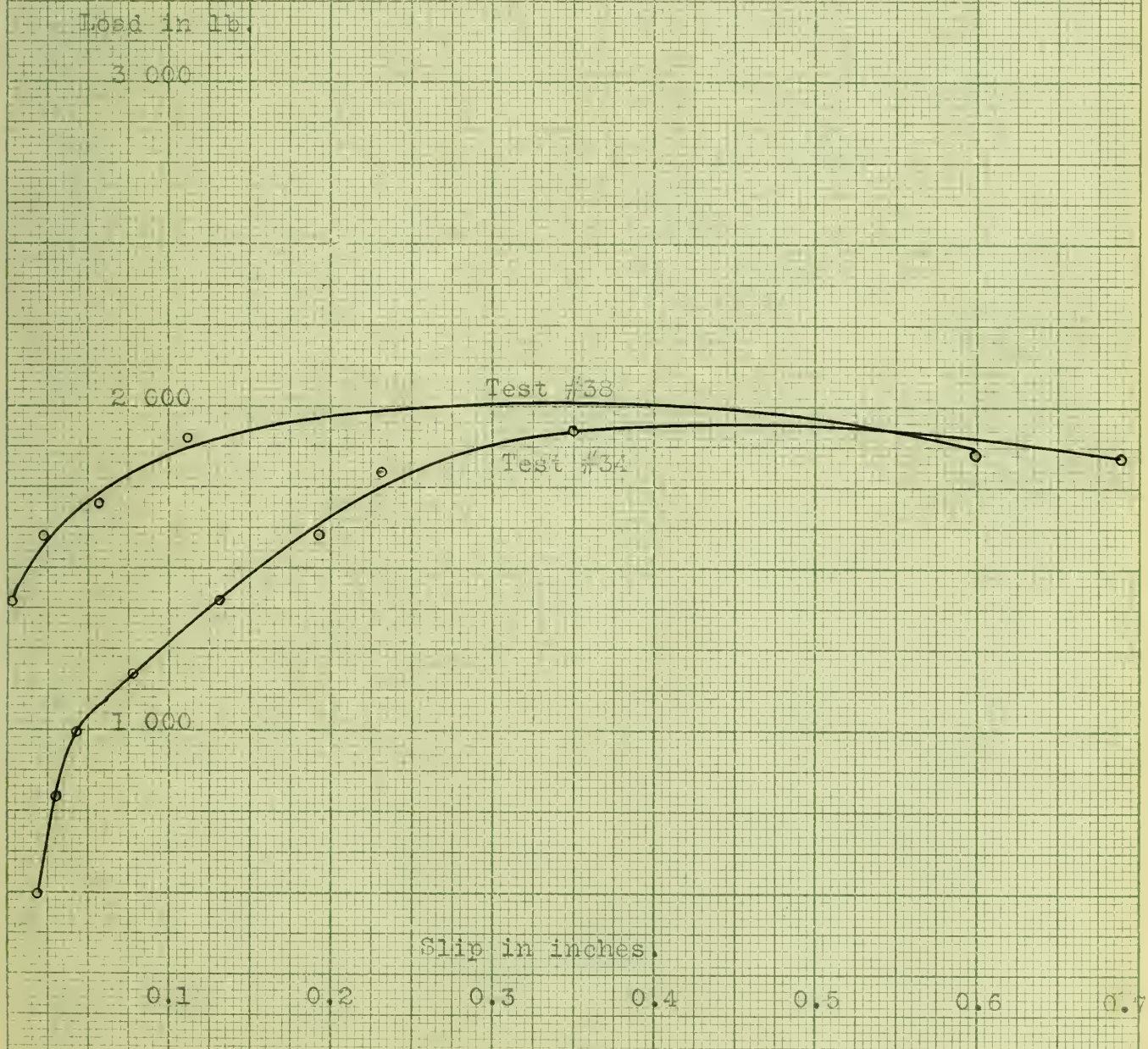

Test #25
Eight clips. Broke
Test #27
Seven clips.
Broke
Test #26
Seven clips.
Broke
TESTS #25, #26, & #27.
Seven and Eight CROSSED CLIPS.
TWISTED TESTS WITH 1/2" ROPE.
Load in lb.
11 000
10 000
9 000
8 000
7 000
6 000
5 000
4 000
3 000
2 000
1 000
Slip in inches.
0.2
0.4
0.6
0.8
1.0
1.2
1.4

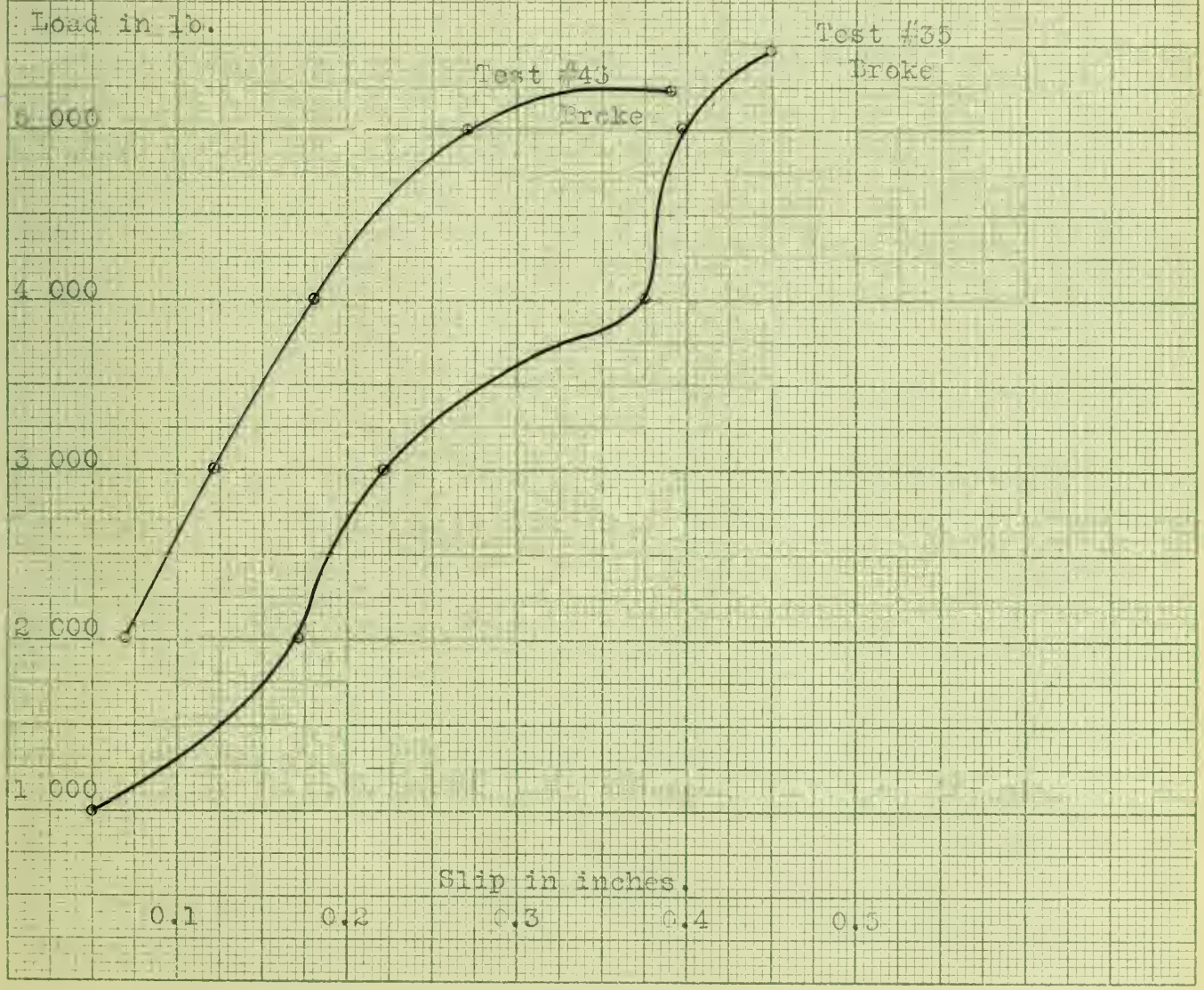
U. OF I. S. FORM 3

TESTS #34 & #38.
ONE CROSBY CLIP.
TENSION TESTS WITH 3/8" ROPE.



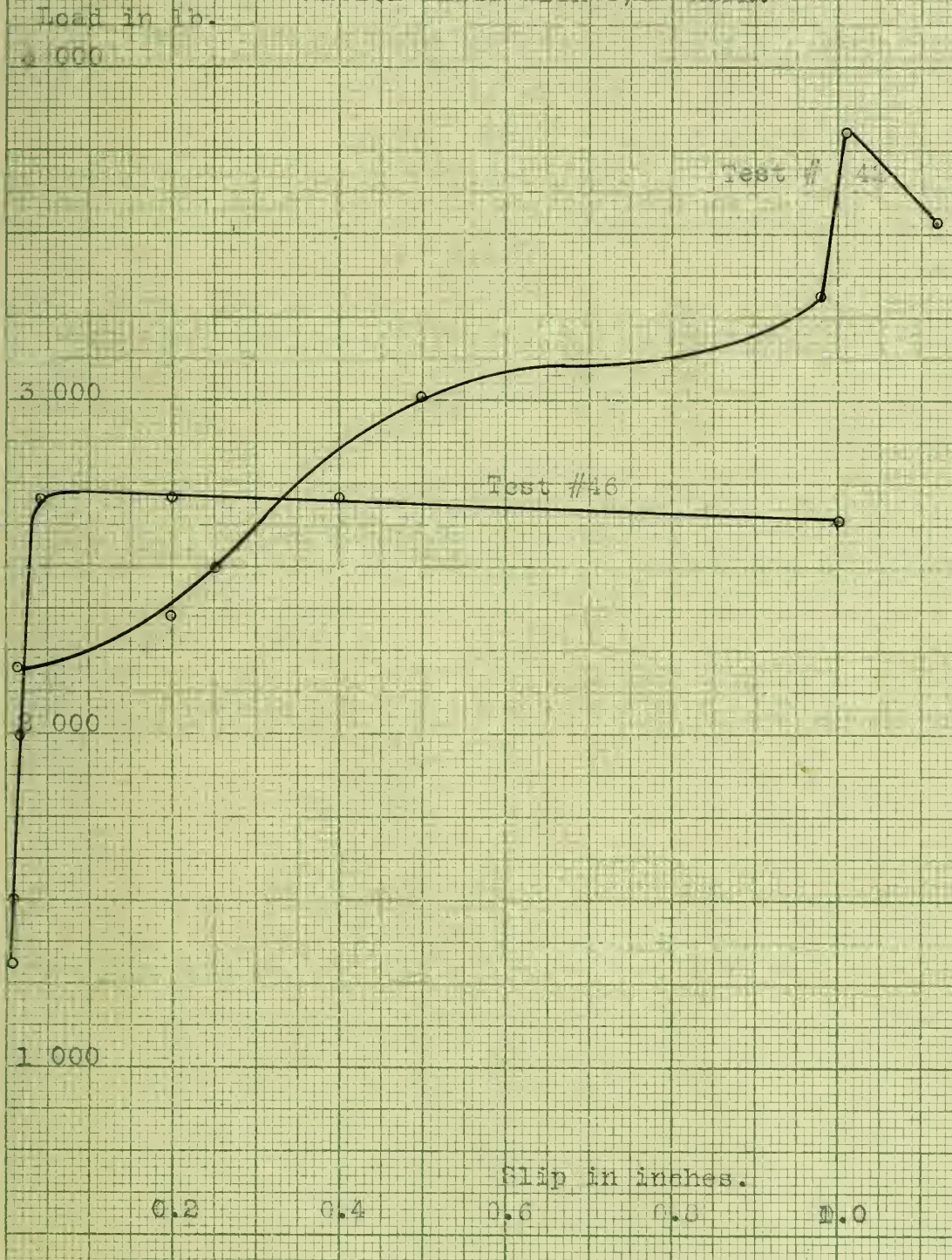
U. OF I. S. S. FORM 3

TESTS #35 & #43.
THREE CROSBY CLIPS.
TENSION TESTS WITH 3/8" ROPE.



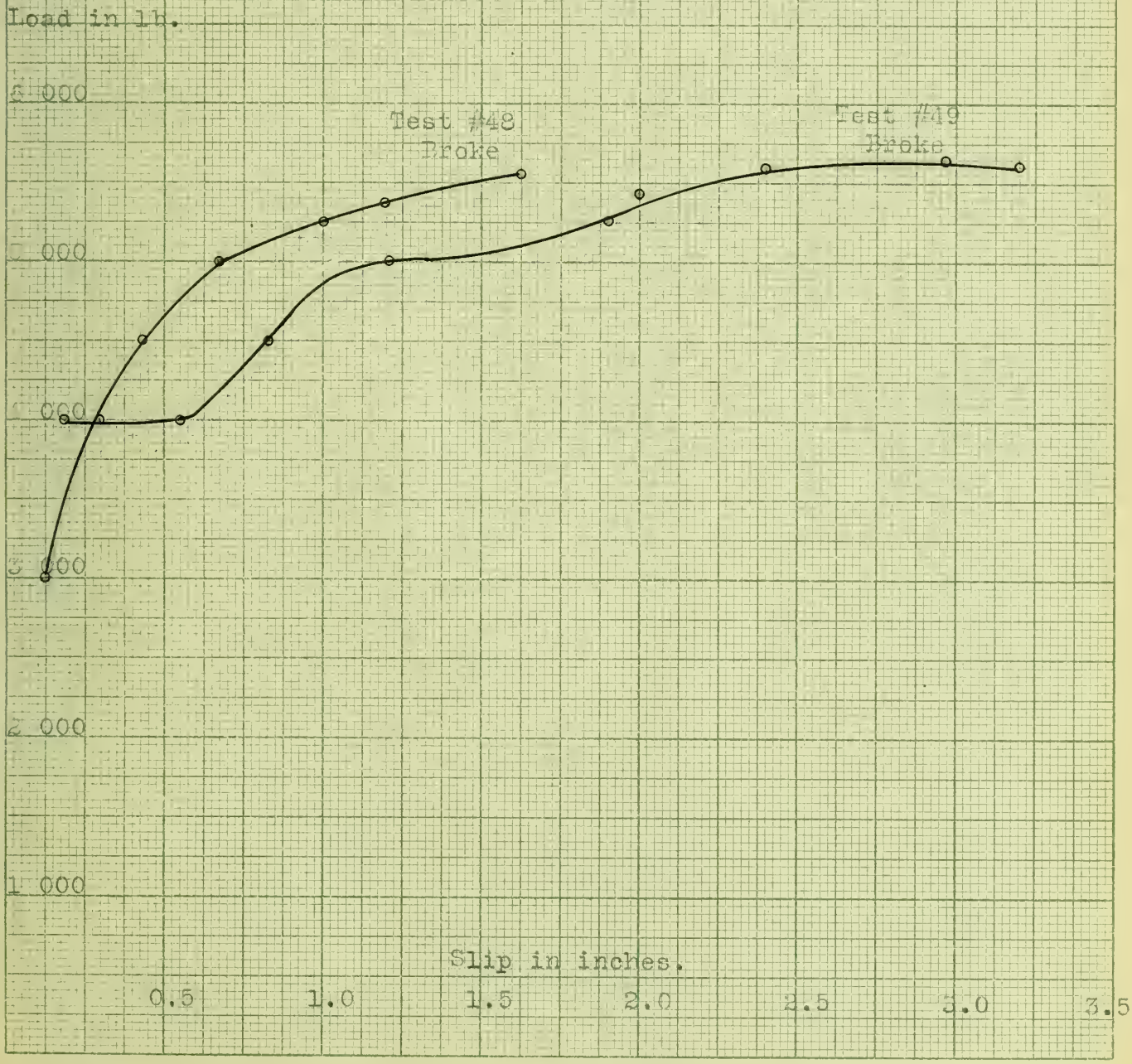
U. OF I. S. S FORM 3

TESTS #42 & #46.
ONE THREE BOLT CLAMP.
TENSION TESTS WITH 3/8" ROPE.



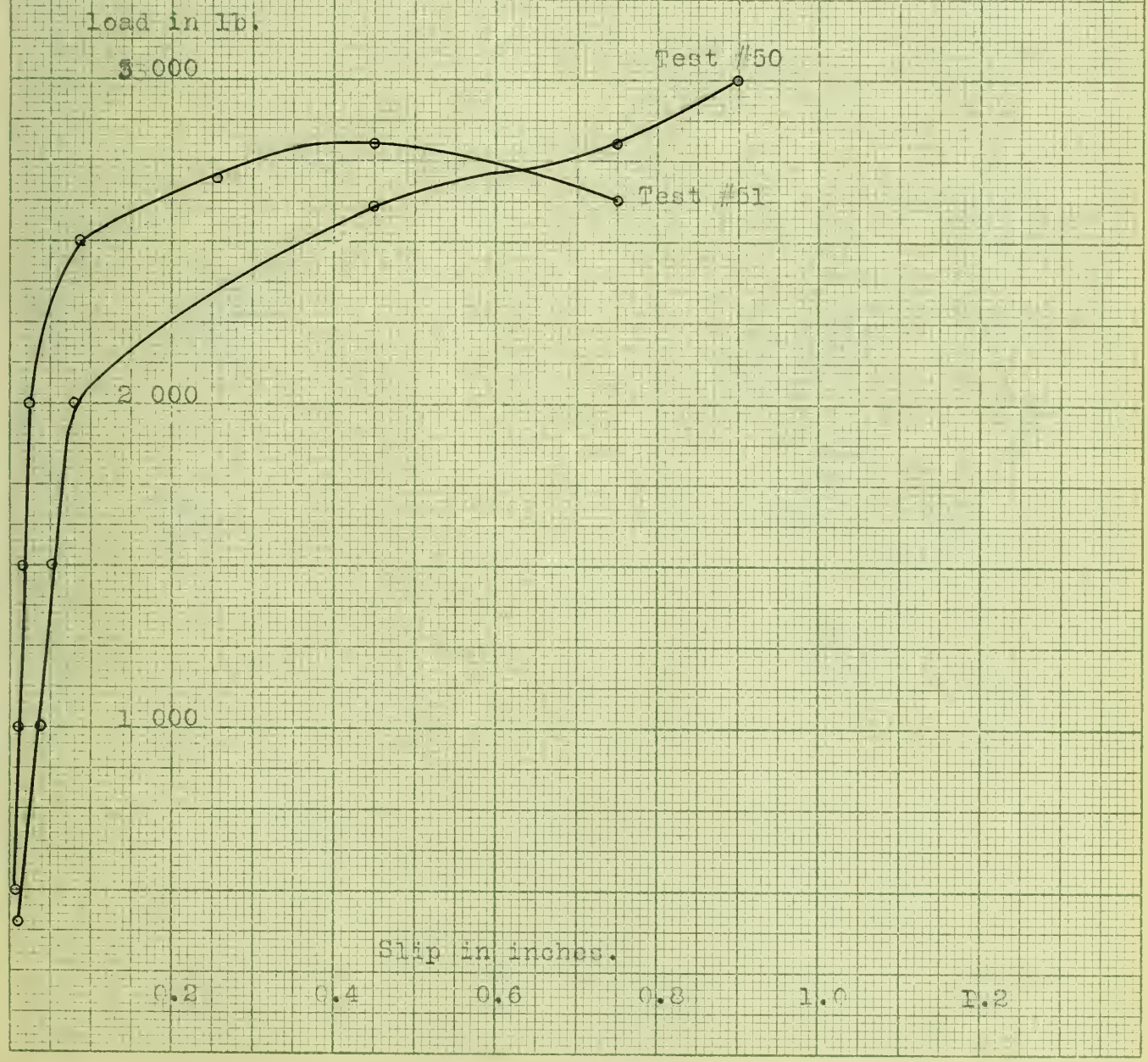
U. OF I. S. S. FORM 3

TESTS #48 & #49.
TWO THREE BOLT CLAMPS.
TENSION TESTS WITH 5/8" ROPE.



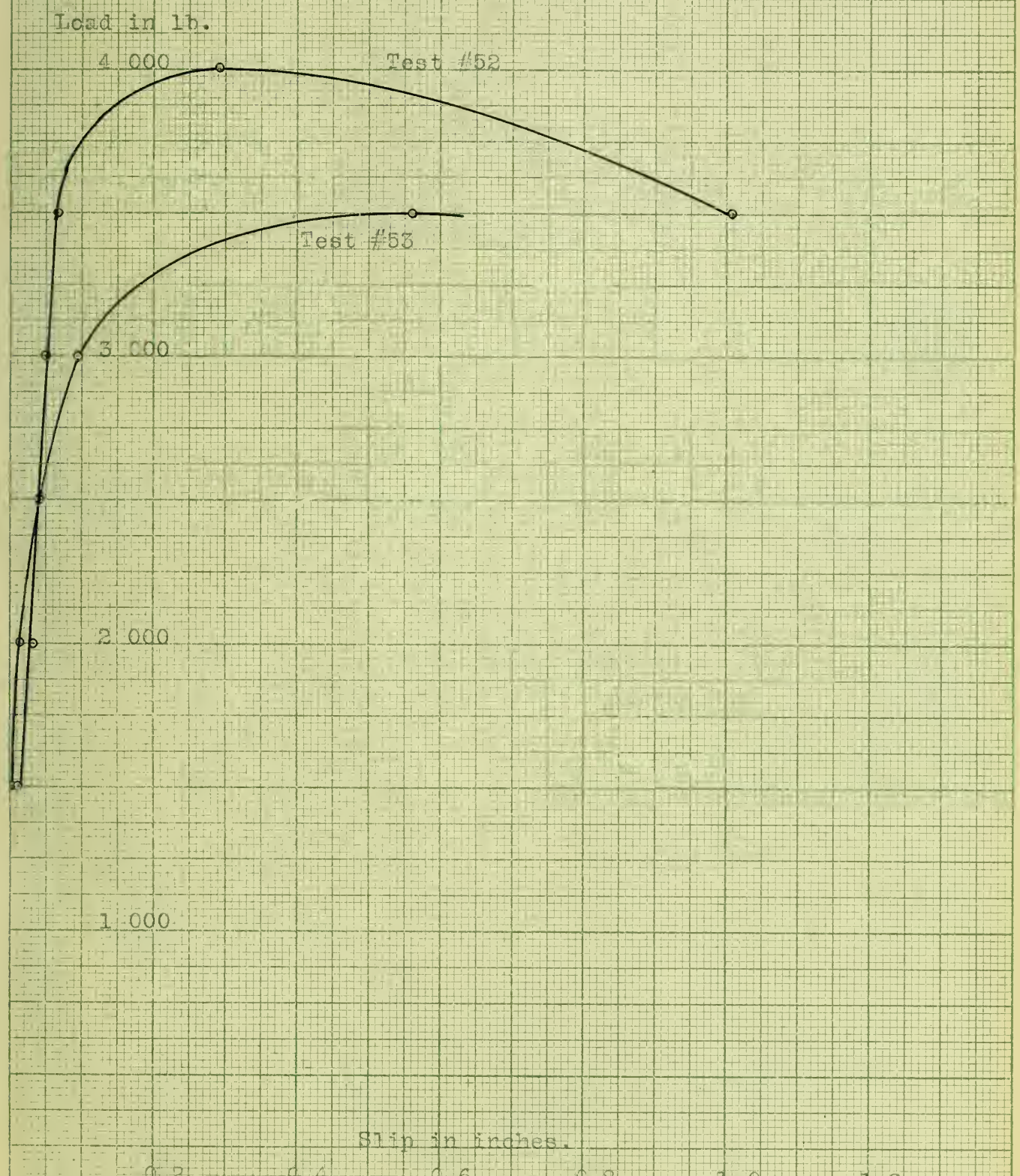
U. OF I. S. S. FORM 1

TESTS #50 & #51.
BABY MATTHEWS CLAMP.
TENSION TESTS WITH 3/8" ROPE.
ONE COMPLETE WRAP OVER 6" PIPE.



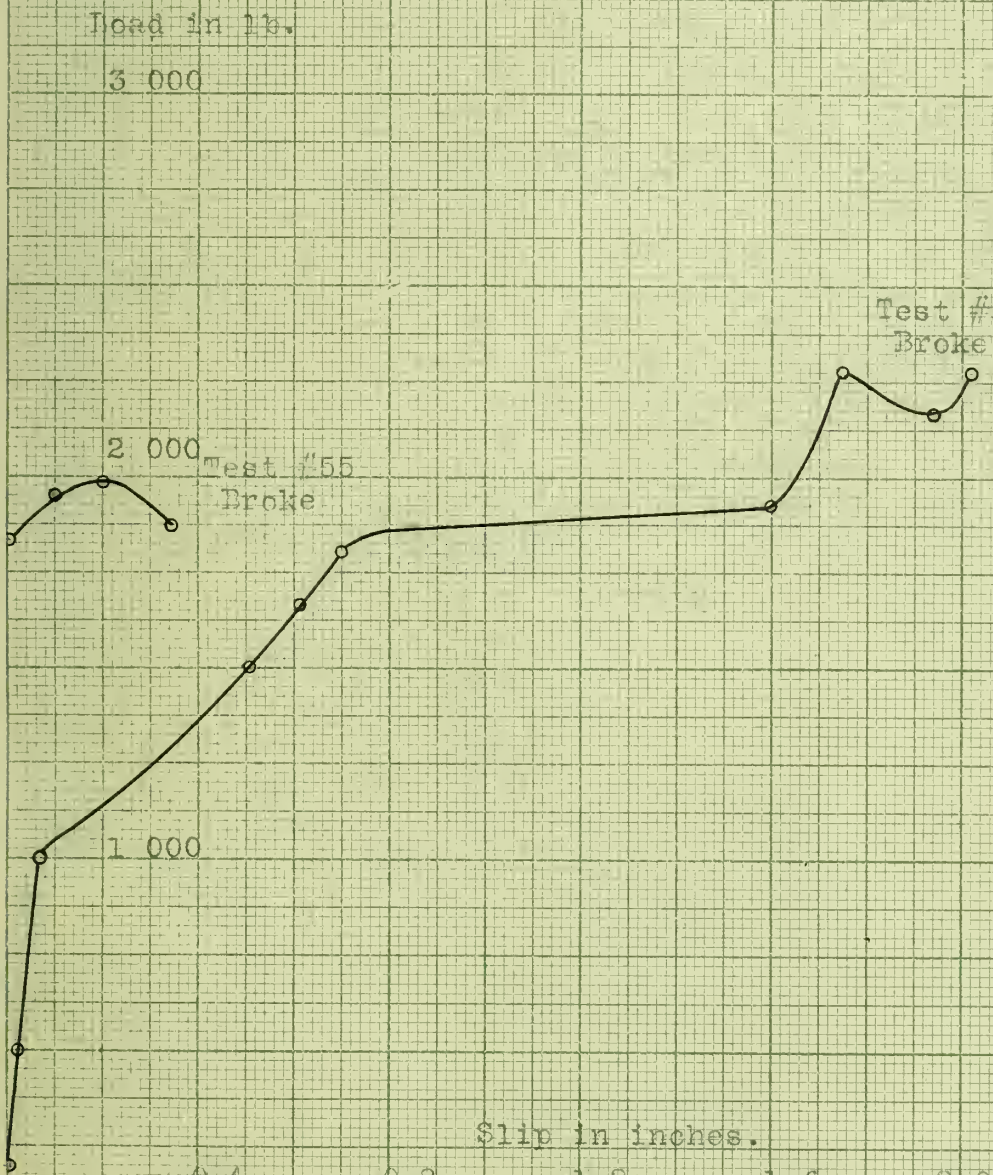
U. OF I. S. FORM 3

TESTS # 52 & #53.
BABY MATTHEWS CLAMPS.
COMPLETE WRAP AROUND 6" PIPE.
TENSION TESTS WITH 5/8" BOLT.



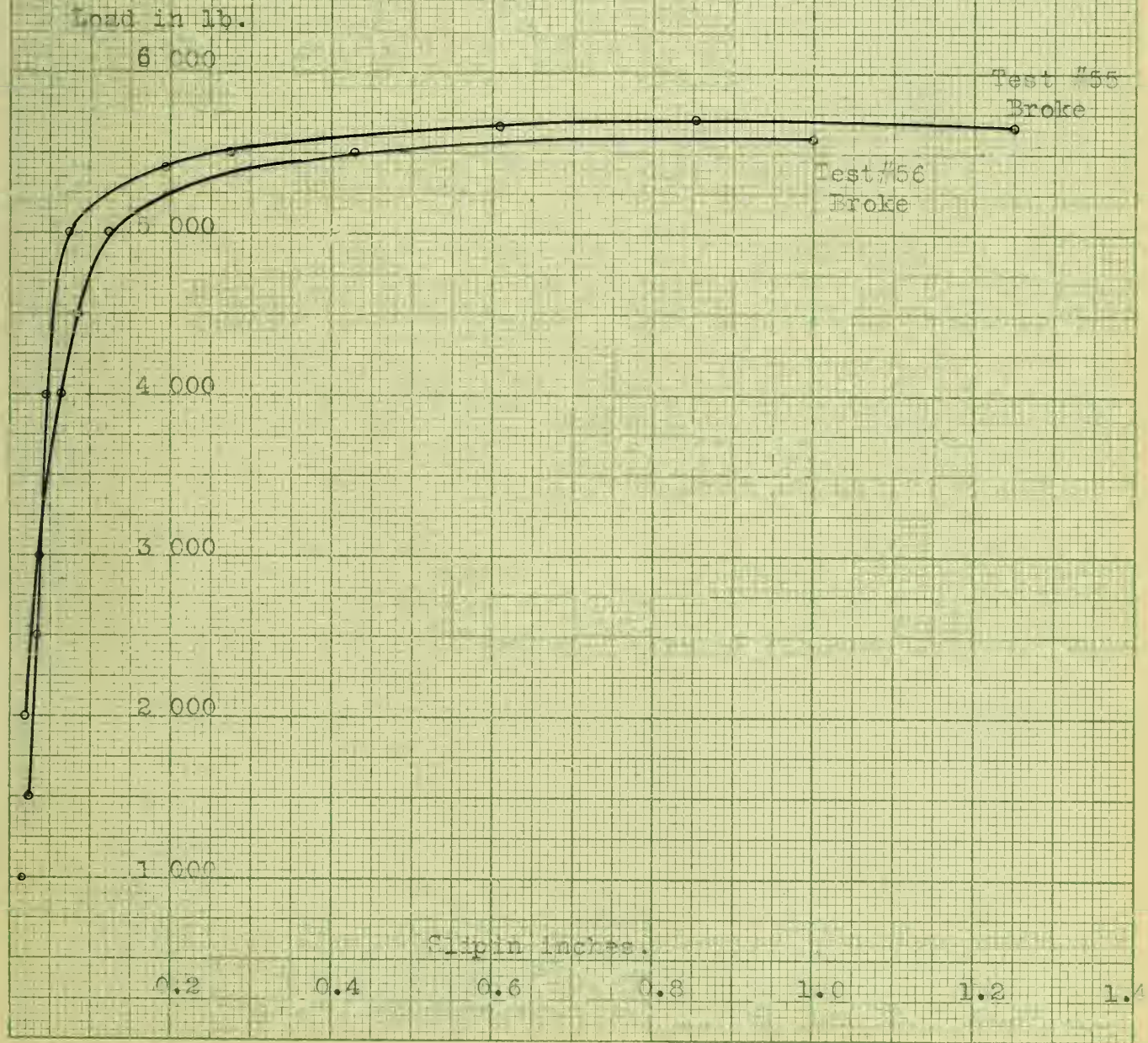
U. OF I. S. S. FORM 3

TESTS #55* & #56*
BABY MATTHEWS CLAMPS.
COMPLETE WRAP OVER 6" PIPE.
TENSION TESTS WITH 1/4" BOLT.
*Tests recorded in old book.



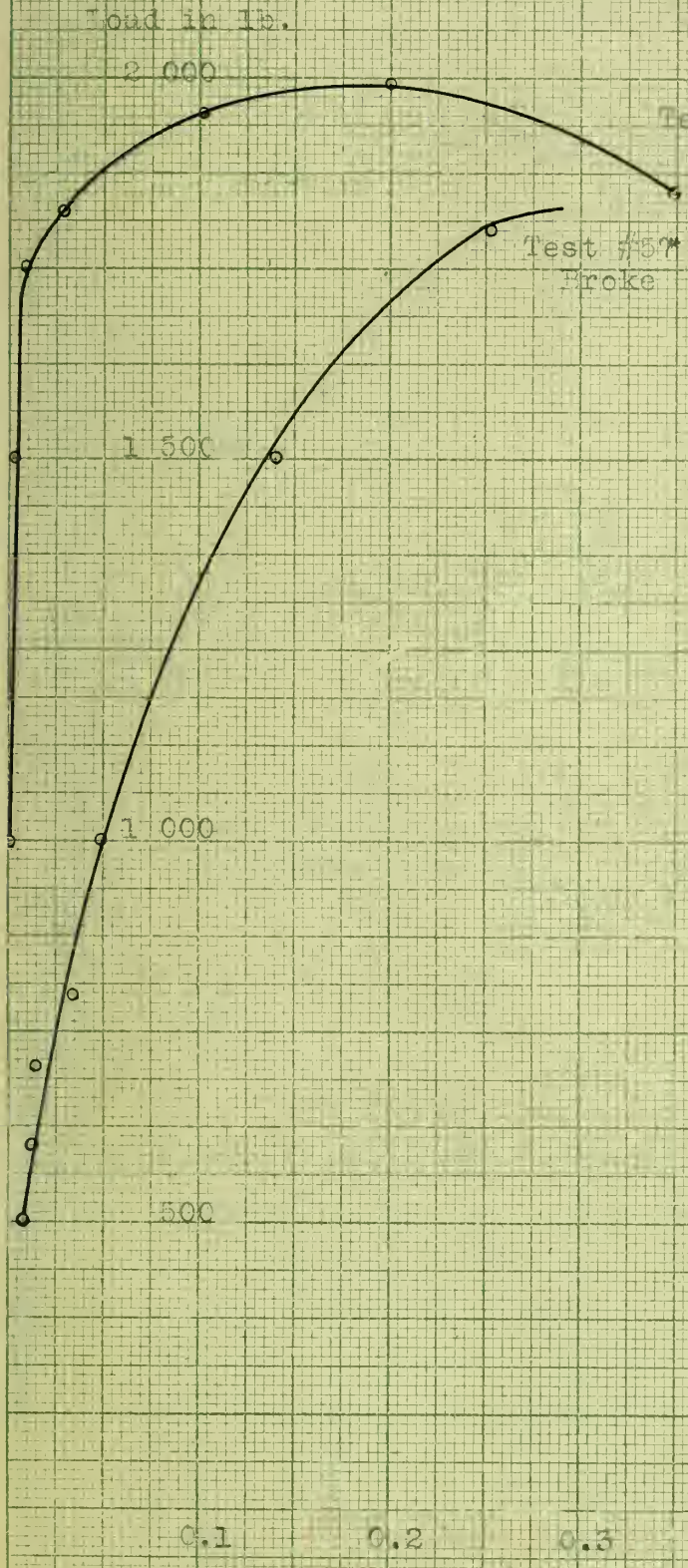
U. OF I. S. FORM 3

TESTS #55 & #56.
TWO BABY MATTHEWS CLAMPS.
COUPLER WRAP OVER 6" PIPE.
TENSION TESTS WITH 3/8" ROPE.



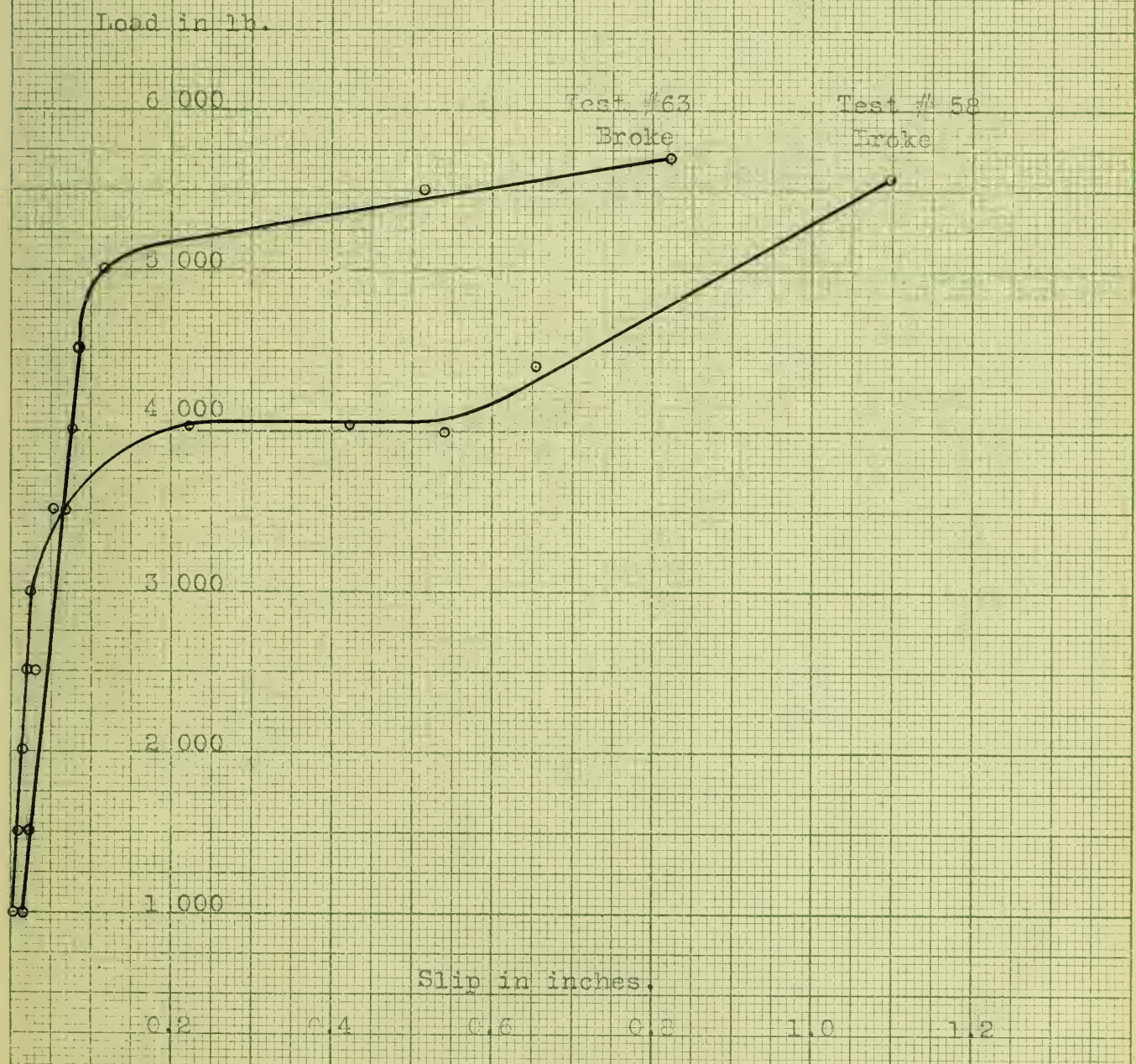
U. OF I. S. S. FORM 3

COMPARING
TESTS #55 & #57*.
BABY MATTHEWS CLAMPS.
TENSION TESTS "ITT 1/4" ROUT.
COMPLETE WRAP OVER 6" PIPE
WEDGE AWAY FROM THE PIPE. #57*



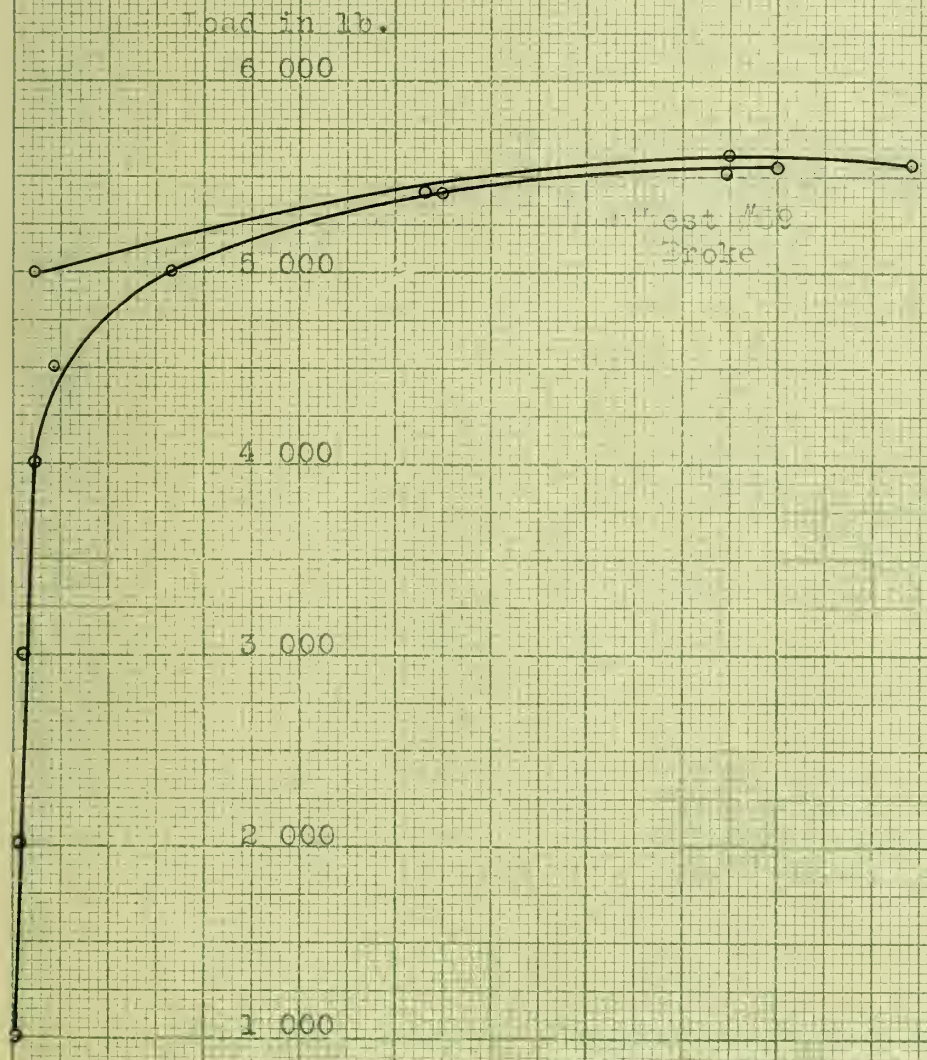
U. OF I. S. FORM 3

TESTS #58 & #63.
BABY MATTHEWS CLAMPS
SLIPTON TESTS WITH 3/8" ROPE.
COMPLETE WRAP OVER 6" PIPE.



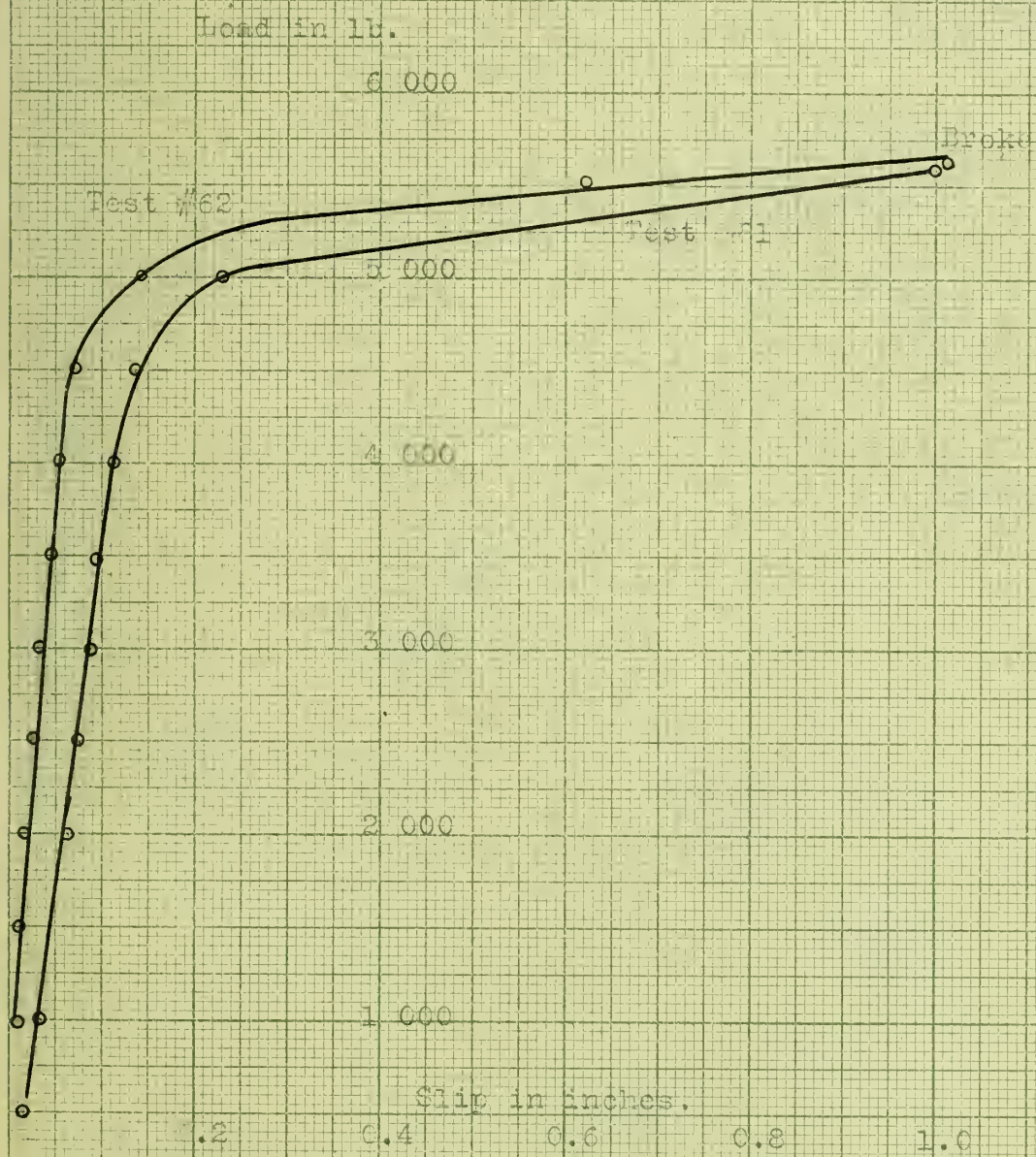
U. OF I. S. S. FORM 3

TESTS #59 & #64.
FLAT BACK GIANT MATTHEWS CLAMPS.
TENSION TESTS WITH 3/4" WIRE ROPE.
CONDUIT WRAP OVER 6" PIPE.



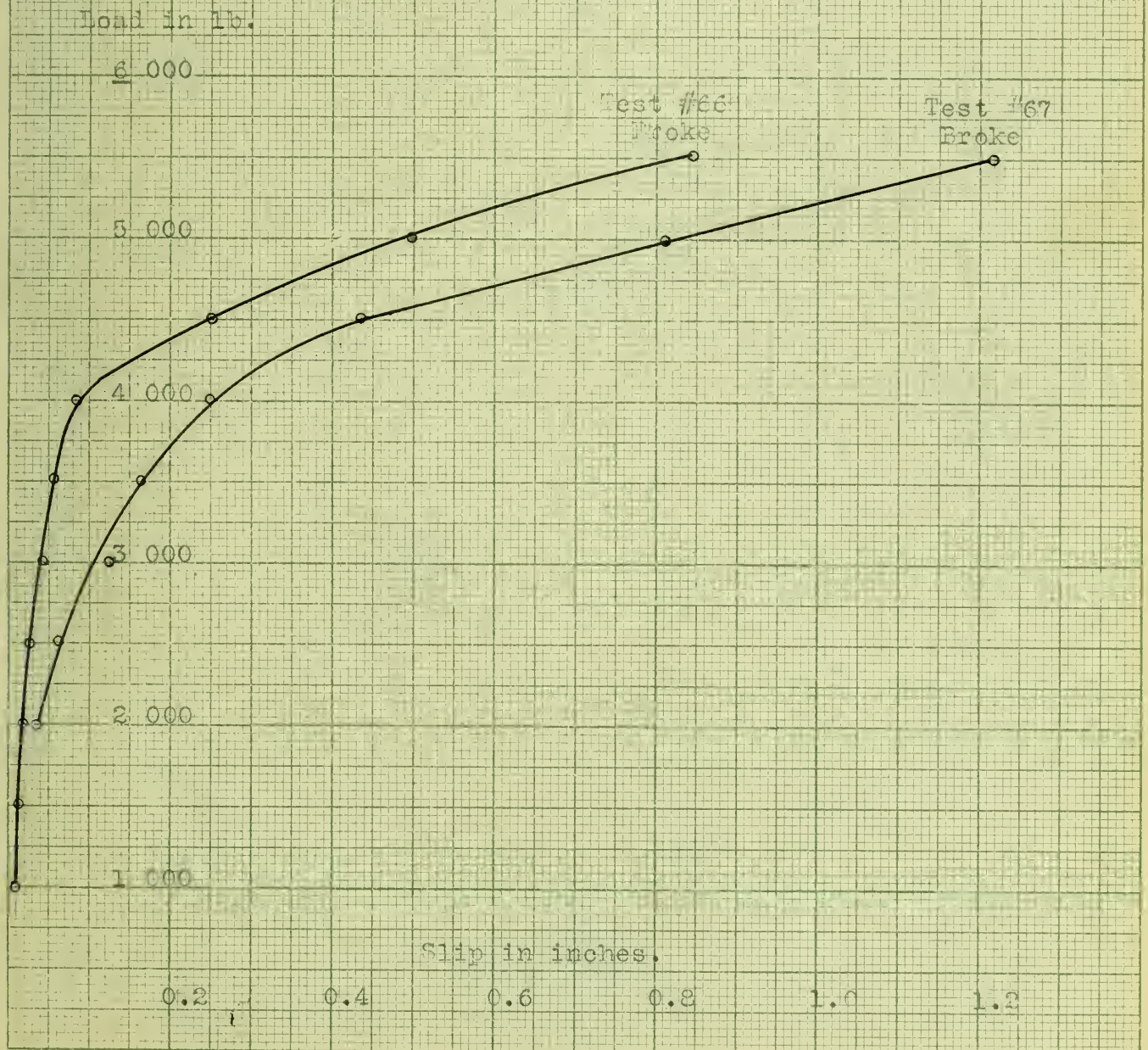
U. OF I. S. S. FORM 3

TESTS #61 & #62.
OPEN BACK GRADE MATTHEWS CLAMP.
"HISTON TESTS WITH 5/8" ROPE.
COMPLETE WRAP OVER 6" IRON PIPE.



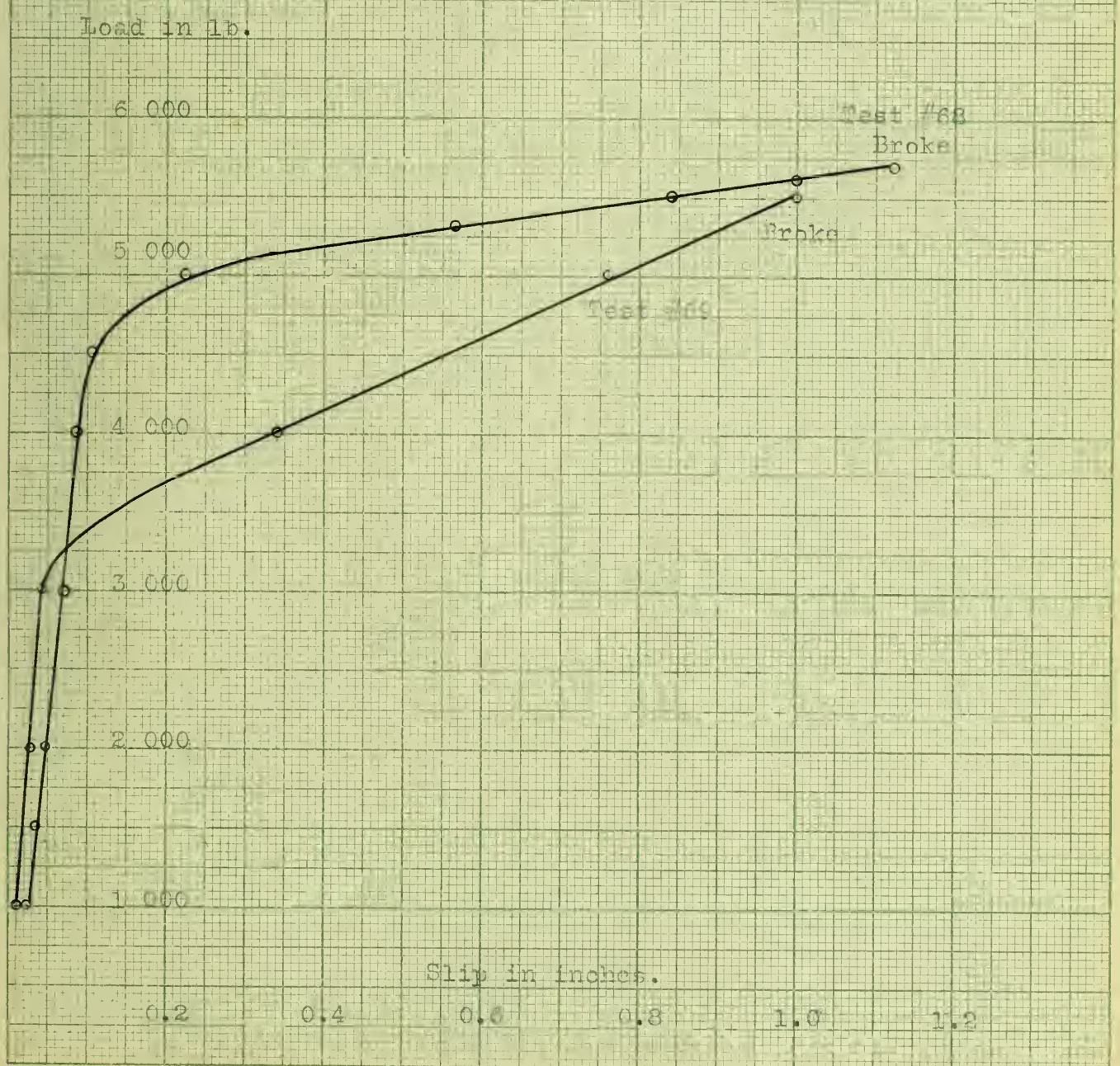
U. OF I. S. S. FORM 3

TESTS #66 & #67
One CROSBY CLIP.
TENSION TESTS WITH 3/8" ROPE.
COMPLETE WRAP OVER 6" PIPE



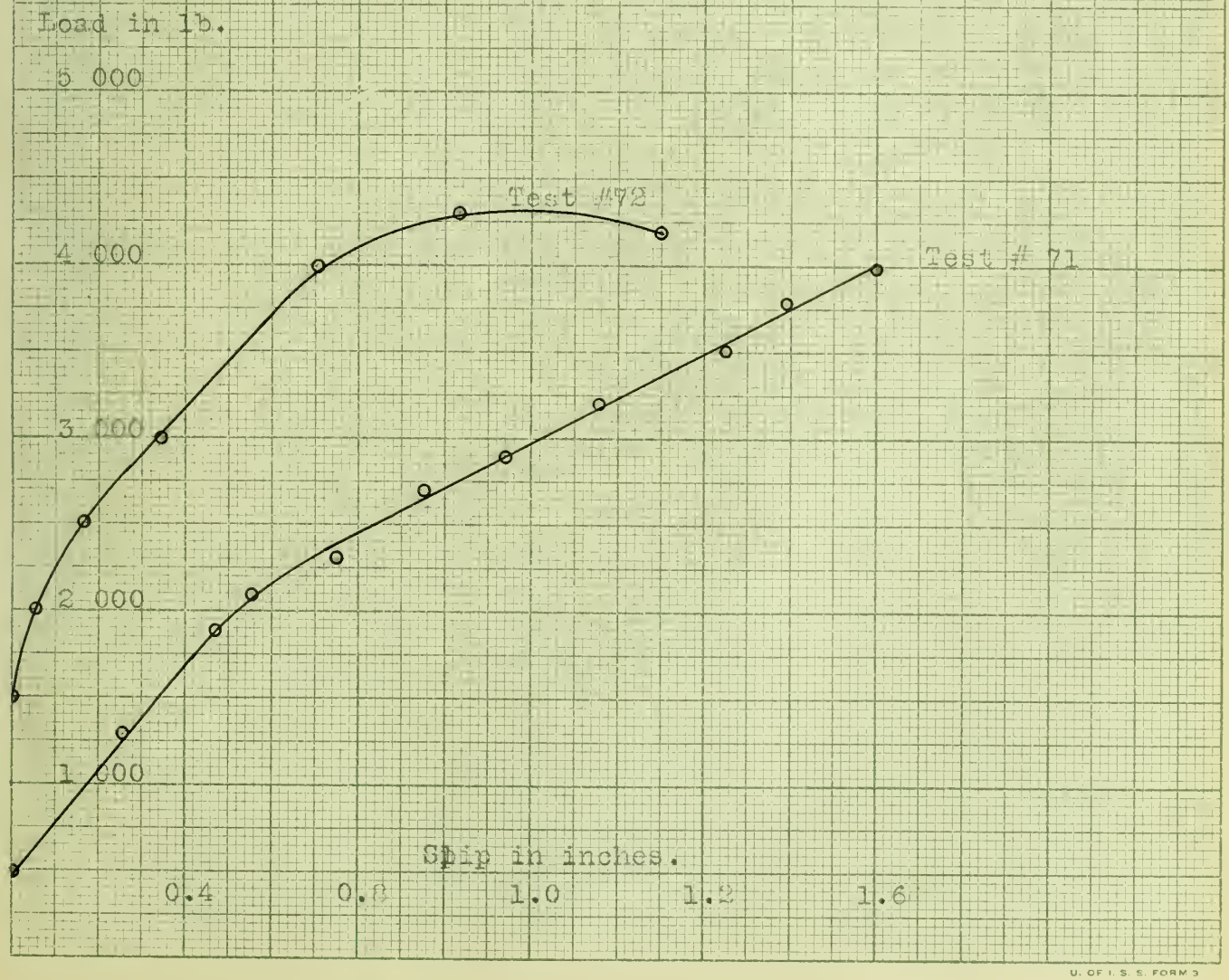
U. OF I. S. S. FORM 3

TESTS #68 & #69.
ONE THREE-BOLT CLAMP.
TENSION TESTS WITH 5/8" BOLTS.
COMPLETE WRAP OVER 6" PIPE.

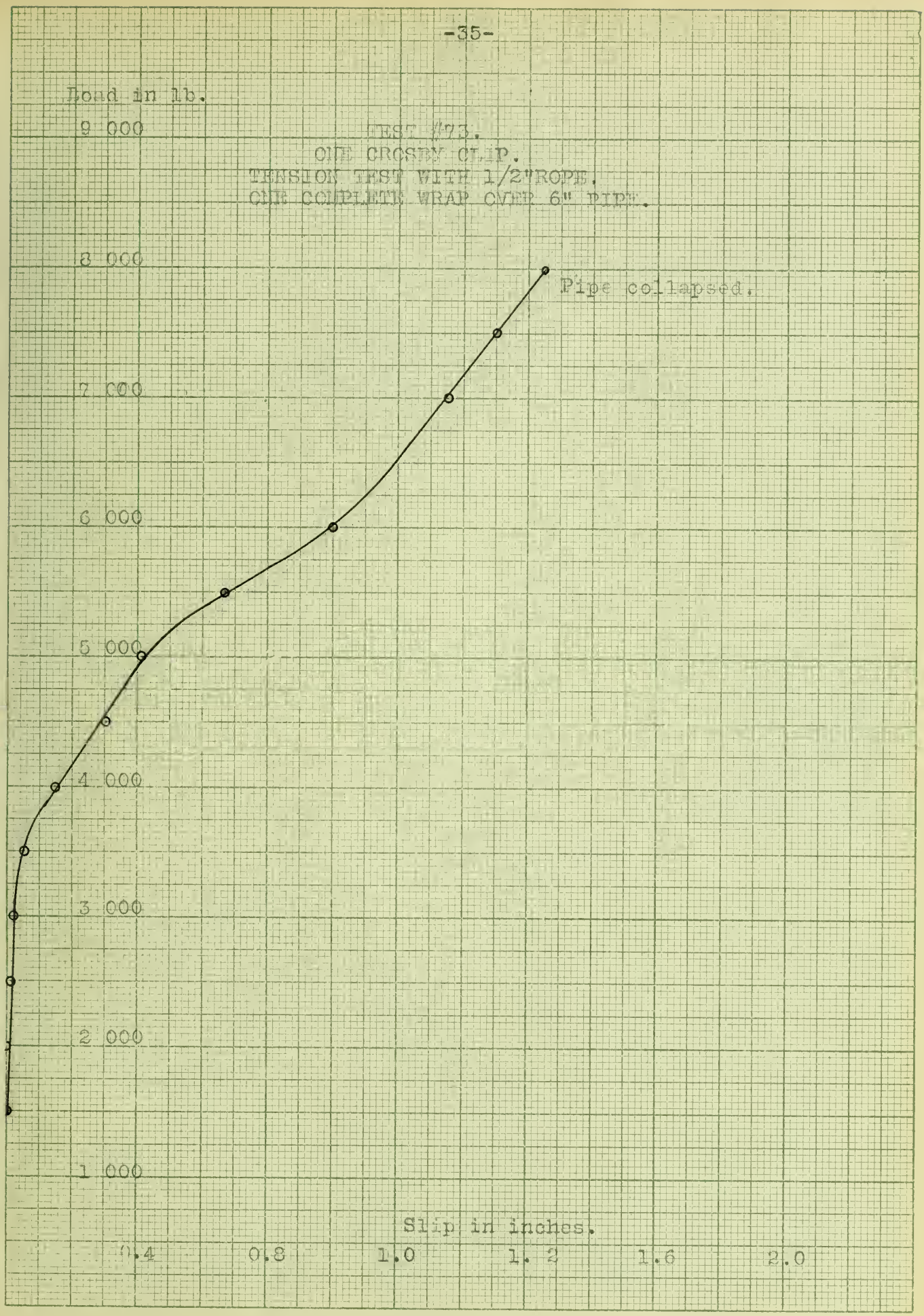


U. OF I. E. S. FORM 3

TESTS #71 & #72.
ONE COOK TWO BOLT CLAMP.
TENSION TESTS WITH 3/8" ROPE.
COMPLETE WRAP OVER 6" PIPE.

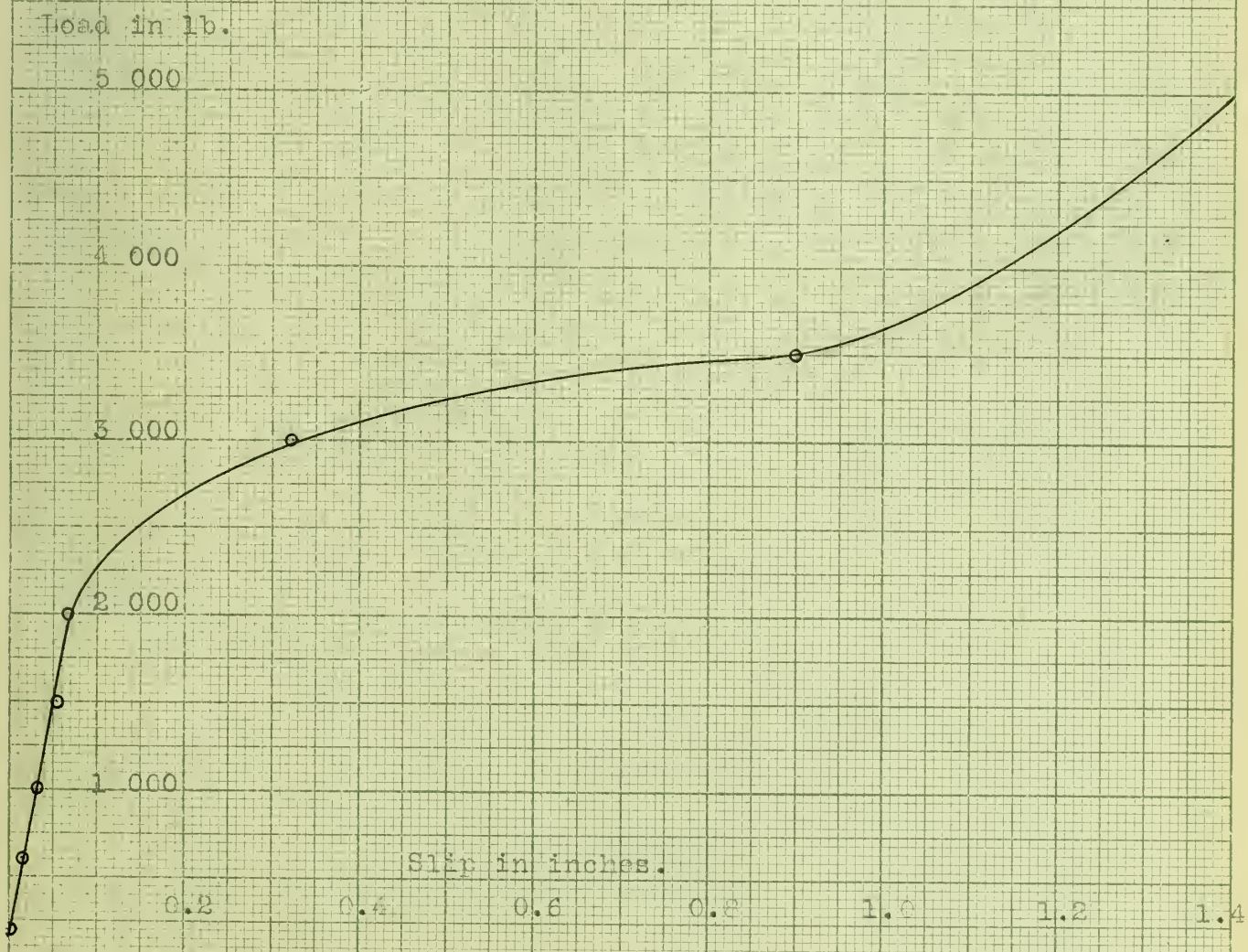


U. OF I. S. S. FORM 3



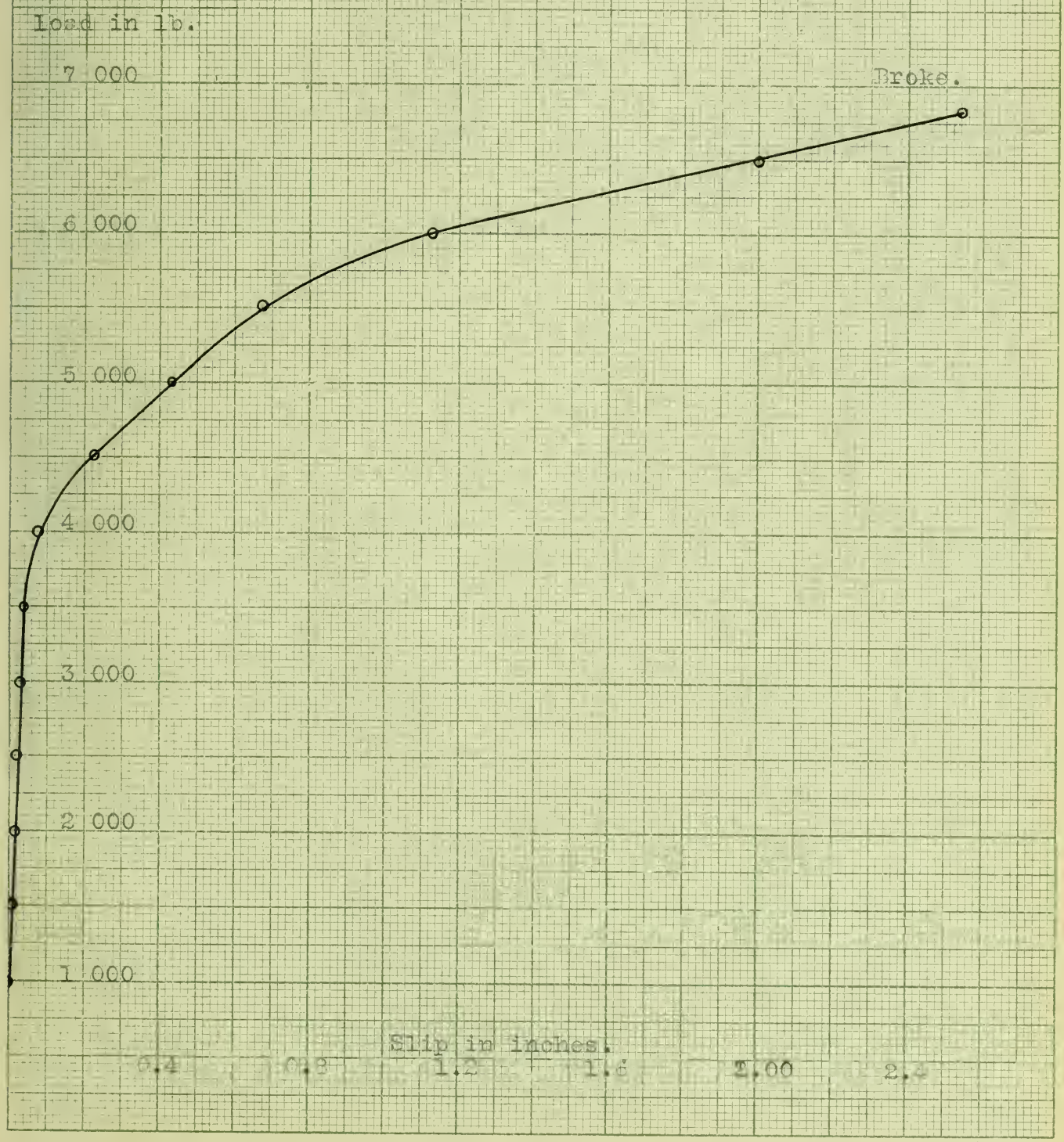
U. OF I. S. S FORM 3

TEST #74.
BABY MATTHEWS CLAMP.
TENSION TEST WITH 3/8" #10 000 STRAND.
OHIO COUPLING WRAP OVER 7# PIPE.

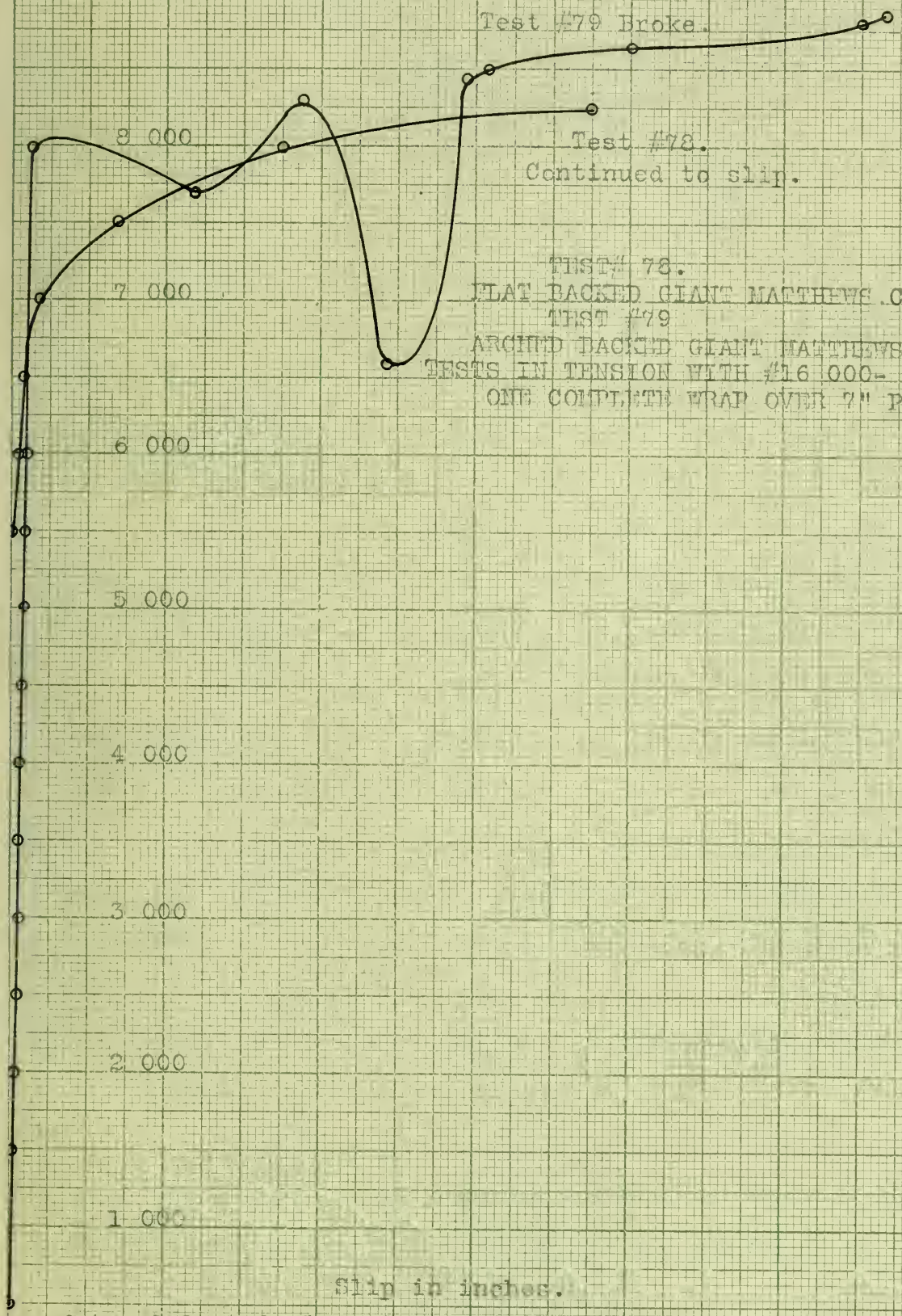


U. OF I. S. S. FORM 3

TEST # 75.
BABY MATTHEWS CLAMP.
TENSION TEST WITH 3/8"-#10 000 STRAND.
ONE COMPLETE WRAP OVER 7" PIPE.



U. OF I. S. S FORM 3



TEST# 78.
FLAT BACKED GIANT MATTHEWS CLAMP.
TEST #79
ARCHED BACKED GIANT MATTHEWS CLAMP.
TESTS IN TENSION WITH #16 000- 7/16"STRAND.
ONE COMPLETE WRAP OVER 7" PIPE.

U. OF I. S. S. FORM 3

Conclusion.

The following conclusions were drawn from the Thesis.

In straight tension; Each clip of the Crosby type added increased the strength of the fastening in full porportion. Each additional Three-Bolt Clamp added to 3/8" rope increased the strength of the fastening porportionately. This same ratio was born out on the tests on the 1/2" rope as far as we carried them, namely up to 6 clips.

With one wrap around a 6" pipe; the Crosby clip on a 3/8" rope had an efficiency of 100%; the Three Bolt, 100%; and the Matthews on both the 1/4" and 3/8", 100%. that is , one clip or clamp was sufficient to break the cable. The Cook clamp gave only about 50% efficiency on series No.II and on series No,I they showed even lower efficiency, probably the wrong size of clamps were furnished for series No. I.

In the series No. III the Matthews clips gave good results on the extra strength rope, giving efficiencies of 90% and 100% on the 10 000lb. rope and the same on the 10 000 lb.

The straight tension tests (Series No. 1) seems to the best for determining the efficiencies of the various clips excepting the Matthews which is not designed for this sort of a stress. The smaller the rope the higher the efficiency of the Crosby clip, this being due to the squeezing action being more effective on the lighter wire.

The order of ease of application of the clips and clamps are; Matthews, first; Cook and Three Bolt, second; and Crosby last. The Matthews clamp is easily slipped over the cable and with a few blows of a hammer the fastening is complete. Of this Type there is a clip which has an open back and the wire may

thrust thru the opening in the back and then the wedge placed. When using the flat type it is almost necessary to remove all the bolts in the clamp and then to reassemble. This operation is slow and tedious especially when a number of clamps are needed. The Crosby requires some time to take apart and then to place. This clip, to be in successful operation depends upon the squeezing power, is very difficult to place when either in the shop or in the field as the bolts must be very tight.

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